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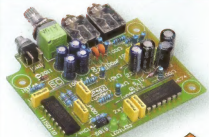

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Publisher's Letter

Nuclear power now not likely in Australia

In the aftermath of the appalling earthquake and tsunami in Japan, and the still unfolding nuclear power station disaster, there has been an inevitable and smug "we told you so" reaction from the anti-nuclear brigade in Australia. Never mind that the nuclear reactors actually survived the most severe earthquake in Japan's history and that it was the following tsunami that caused all the damage. Never mind that any nuclear power station which might (now possibly never) be installed in Australia would be a modern design with far more safeguards than the old reactors in Japan. Never mind that Australia is not subject to severe earthquakes and tsunamis in any case. This is a major setback for nuclear power which will last many years.

So the rallying cry from the greens is that we must rely on renewables, which as most people are now aware, are much more expensive than coal or gas-fired power stations, and which require back-up with an equivalent capacity of yes, coal or gas-fired power stations.

On a related topic, concerning that dreadful "carbon pollution" and "climate change" (caused by you and me), is a recent press release from Ausgrid, which is the new name for Energy Australia, the major electricity retailer (recently sold to TRUenergy) in Sydney. Ausgrid are urging people who own electric hot water systems to hurry and replace them while government subsidies are still available to install "energy efficient" gas-fired, heat pump and solar hot-water systems.

Readers may not be aware of it but electric hot-water systems have not been allowed in any new homes or dwellings since last year and no such systems will be able to be replaced from 2012.

Now it is not clear just how universal this ban will be but there are vast numbers of hot water systems installed in home units, offices, shops and commercial premises where it just won't be possible to replace them with gas-fired or solar systems. Is this yet another misguided government attempt to make us all more energy efficient? By the way, the press release includes this ridiculous statement: "Every time you have a hot shower powered by electricity, you're using the same amount of energy that it takes to run 150 televisions at once".

Now it is true that electric hot-water can account for around 35-40% of total household electricity consumption but the above statement is highly emotive rubbish. Yes, the heat energy being delivered from your shower head is at very high rate (albeit it has been accumulated in the tank over a period of maybe half an hour or so) but that is akin to saying that the petrol coming from the bowser at your local filling station is equivalent to a large power station – equally ridiculous.

I feel that the whole process of using government subsidies to get people to replace perfectly functioning hot-water systems is another huge waste of resources, especially as those same systems may last for many more years (particularly if their sacrificial anodes are replaced every five years or so). Yes, gas-fired systems are more energy efficient but the cost of operation under present tariffs is about the same as for an electric off-peak system. Solar hot-water systems are generally more efficient but unless properly installed, they can use lots of electricity or gas in their booster when the sun is not present.

So even if a conversion from electricity to gas or solar is promoted, the overall energy savings may not be that large. And the process of encouraging people to scrap functioning units simply ignores the large amount of natural resources which have to be used to manufacture the new unit.

For my part, I am going to keep my off-peak electric hot water system going for as long as I can. This may not conform to the current government doctrine but I regard it as being more environmentally and fiscally responsible.

You can find the current federal government edict on hot-water systems at: **www.climatechange.gov.au/what-you-need-to-know/appliances-and-equipment/hot-water-systems/phase-out**

Leo Simpson

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Mitsubishi i-MiEV is a joke

I'm really impressed by your March 2011 issue, featuring the Mitsubishi electric car, the i-MiEV; but not by the i-MiEV, nor your conclusions. The acknowledgement lists Malcolm Faed, who electrified an ordinary ute (SILICON CHIP, June 2009). He halved its top speed, reduced its range to just a quarter, and then needs all morning, and some, to recharge it.

He's an amateur. Let's see what the professionals can do. Well, the performance of the i-MiEV is depressingly similar. The top speed is only 130km/h and what's the 70-to-100 acceleration like for over-taking? The range is a maximum 160km but really about 100km; it only gets halfway to grandma!

Charging is only "fast" with a rare 3-phase device and still takes 30 minutes to 80%. "Real" charging takes seven hours! That's a 7-to-1 charge-to-use ratio! The article finishes by claiming "these new electric cars are definitely practical . . ." For what? – short trips and long waits?

I suggest a diesel hatchback would blow this out of the water and use bio-diesel if you want to be greener. When I saw Malcolm's electric ute on the cover of the June 2009 issue of SILICON CHIP, along with the "jolly clever" battery meter, I thought – great irony. Now I realise you were actually serious! You really think electric cars are a "good idea".

I'm off to watch Top Gear (how did you guess) for some common sense. That's the real Top Gear too.

Allen Reynolds,
Glenfield, North Shore City, NZ.

Leo Simpson comments: *thanks for your letter, Allen. It gave me a good laugh.*

I actually agree with you and think that electric cars are never likely to be seen on our roads in large numbers. Check my Publisher's Letter in the January 2009 issue – I have not changed my opinion since then.

Having said that, we feel that we should report on developments in electric cars. Maybe, just maybe, there might be enough developments in battery technology to make them really practical. But the i-MiEV is a fun car to drive and it might be quite popular, depending on its sale price and the ultimate cost of petrol.

By the way, I also agree with you about the real Top Gear!

Malcolm Faed comments: *electric cars are not for everyone. With the current battery technology, they are best used as a very economical, low-maintenance second car if you need one, and take the other car when you need to go to see Grandma, or feel the need to go much faster than 100km/h (in NZ).*

*As hydrocarbon-based fuel costs dramatically increase (remember 2008: **http://en.wikipedia.org/wiki/2000s_energy_crisis**), whether in our lifetime or our kids, we will all begin to think very differently about our needs and wants. Where we live, work, shop, socialise and holiday. The*

Power factor correction for appliances could be mandated

In the Mailbag pages of the March 2011 issue of SILICON CHIP, you wrote in response to M. R., that "all these power factor correction gizmos promoted to domestic consumers have no benefit".

You are of course entirely correct – as far as the domestic consumer is concerned. But no benefit to anyone? What about the electricity utility?

While we're throwing about basic equations, how about $P = I^2R$? Current out of phase with voltage delivers no real power, to be sure – but it does lead to quite real losses in transmission lines. The consumer doesn't pay for that (directly) but the utility does.

Granted, the effect in a domestic setting is minuscule but of no benefit? None at all? Reducing transmission line losses saves someone some money, somewhere.

David Meiklejohn,
Macquarie Fields, NSW.

Comment: the thrust of our rejection of these products is that they have no benefit to consumers. After all, this is why they are being sold; not as a benefit to the electricity distributors.

The effect of these gizmos is very small in any case. They can only provide power factor correction for a particular motor-driven appliance at the time it is being used. At all other times, they provide a leading power factor which might offset lagging power factor from appliances in other households.

If the electricity retailers decided that power factor correction of motor driven appliances was really desirable, they could have the standards for these appliances changed so that the optimum capacitors were fitted in every case. That would be only a small cost to the manufacturer and would have maximum benefit for the life-time of the appliance.

To be specific, power factor correction capacitors could be added to refrigerators, freezers, dishwashers. washing machines, air-conditioners and swimming pool pumps. Some brands may already have power factor correction.

However, there is another possible scenario where power factor correction of motor-driven appliances might be worthwhile and that is where a household is using an off-grid solar system. In these cases, power factor correction means less load on the inverter. Again, the power factor correction capacitors would have to be installed in the individual motor-driven appliances.

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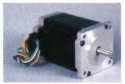

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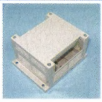

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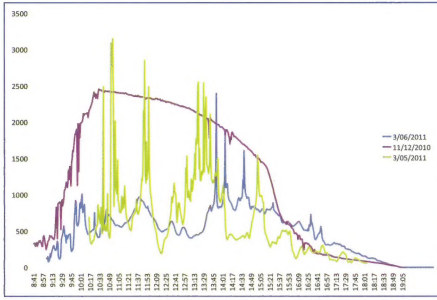

This graph shows the power produced by the writer's 2kW photovoltaic array over three separate days. Note the variations in the green and mauve curves.

Solar panel generation report

I have a 3kW photovoltaic array on a roof with a 20° east facing slope, in a valley which runs north-south. There are also trees on all sides, which influence the time the Sun "rises" and "sets" for the panels.

An attached graph shows the daily power produced since purchase, while another (reproduced here) shows the pattern of production for three days.

I have noticed that the panels are very much geared to bright sunlight; even high cirrus clouds cause a marked drop-off in power. They are also sensitive to temperature. I washed off the dust and the power spiked rather than remaining high.

Now to the questions: when the PV rebate comes to an end and the amount paid for PV generation drops (call me a sceptic), would it be possible to have the inverter disconnected from the mains, connected to a separate circuit (perhaps red outlets) and use a 12V-to-230V inverter to provide the input signal to ignite the inverter? This power could then be used to drive reverse cycle A/C or heating at "no cost" during the day.

Also, I know a licensed electrician has to do the mains wiring but what about 230V wiring from the likes of above or from a portable generator set?

Name & address supplied but withheld at writer's request.

Comment: your graphs yet again show the erratic nature of power generation from solar panels. Since the electricity grid has to cope with all the variations from solar and wind power, it actually needs the capacity to deal with the sudden cessation of these "green" power sources at any time. Inevitably, this makes it much more expensive to provide electricity to all consumers.

As far as running a grid-feed solar system independent of the grid is concerned, this need has been highlighted recently in the aftermath of natural disasters such cyclones, floods and bushfires. When there is a general blackout, a grid-feed solar system on your roof is rendered useless. We are investigating how such systems might be able to provide power to a household in these circumstances. Naturally, any such modification would have to meet all safety regulations.

electrification of the vehicle fleet is one way to help maintain our current lifestyle into the future.

*The motivation for using an electric car is quite varied from person to person, from environmental to economic. Some like to reduce their CO_2 impact, others reducing dependency on foreign oil, energy security, self-sufficiency, minimising running and fuel costs, removing local pollution sources, keeping energy costs within your country, reducing our unsustainable footprint on this planet (**http://wwf.ca/newsroom/reports/living_planet_report_2010.cfm**) or simply because they are new, and I am sure I have missed some.*

Conversely the reasons for not supporting electric vehicles are many and varied; mostly centred around current price, availability, size and range. However just like flat screen TVs, the prices will reduce and the performance will increase with more products and competition.

*I am off to watch Robert Llewellyn on Fully Charged TV – **www.youtube.com/user/fullychargedshow***

Mitsubishi i-MiEV should have in-wheel motors

I was absolutely horrified by the terrible design of the Mitsubishi electric car featured in your February 2011 issue. Just what is wrong with automotive designers? They are so fixated on the design of petrol and diesel vehicles that they haven't the faintest idea how to design an electric car at all.

Firstly, since 1910 is has been known that the proper way to design an electric car is to use "in wheel" motors wired in series. This completely removes any need for a differential, with a great saving of weight and an increase in drive efficiency. Modern permanent magnet motors designed for this application are available and reach efficiencies of well over 90%.

The motor control system seems pretty poor too. With modern switching FET control elements, a PWM system should run almost cool with the sort of heatsink shown in the photos. I base this on two small electric vehicles I have built.

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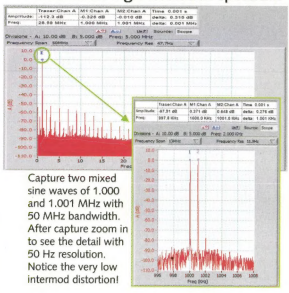
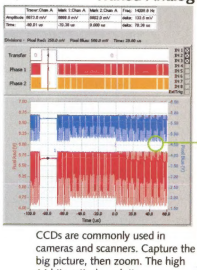
"It has been a fantastic instrument and solved the very difficult waveform observations that I have needed to complete in the last few months." R Dunn, Australia

Wideband high resolution spectrum

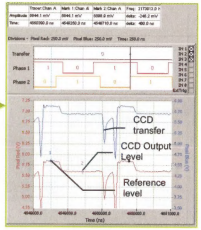


Capture two mixed sine waves of 1.000 and 1.001 MHz with 50 MHz bandwidth. After capture zoom in to see the detail with 50 Hz resolution. Notice the very low intermod distortion!

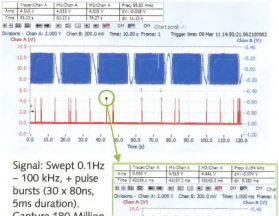
Mixed Analog + Digital Signal Capture



CCDs are commonly used in cameras and scanners. Capture the big picture, then zoom. The high 14 bit vertical resolution means you can qualify 12 bit CCD's.

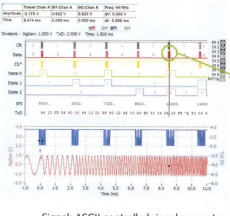


1.5 MSPS stream to disk



Signal: Swept 0.1Hz – 100 kHz, + pulse bursts (30 x 80ns, 5ms duration). Capture 180 Million samples, 120 secs duration. Zoom on the tracer. See the pulse burst detail. What other system can do this??!!

Protocol Decoding



Signal: ASCII controlled signal generator. Uart transmitter sets frequency, which outputs SPI messages to DDS. Decode Uart, and SPI. Display signals. After capture, zoom on one byte of SPI.

Electricity & NBN should be underground

Following the recent spate of natural disasters and the failure of many infrastructure items, particularly electricity and pumping systems for water and sewerage, it may be time to look at an alternative system that can be placed at minimal extra expenditure.

With the proposed roll-out of the NBN (national broadband network) and connection of fibre to the home, electricity distribution suppliers should look at piggy-backing a new supply system with that roll out. Fibre systems are not subject to the same problems as a copper system if power supply insulation breaks down, so the two can be placed in the same trench with little risk.

Using the same technology as the single-wire high-tension DC system employed in the Bass Link (between Tasmania and the mainland), power distribution could be moved underground at a relatively low cost, meaning less risk of interruption to supply during storms, fires and most flood situations. It would also reduce the risk electrocution and also of fires caused by falling power lines.

Don Pearce,
Gledhow,WA.

In my opinion, Mitsubishi haven't done electric cars any favours at all. If a retired engineer like myself can see ways to increase the range by about 30%, while reducing weight and simplifying construction, then I reckon their designers are not even trying seriously to make a decent electric car.

So many other designs have made exactly the same errors. You would not design a jet aircraft exactly the same as a piston-engined plane; neither do you build an efficient electric car like a petrol one!

Clifford Wright,
Helensville, NZ.

Comment: as we understand it, in-wheel motors have not been adopted for electric cars because they present suspension problems, with high "unsprung weight". It is also not at all clear that having two or more in-wheel motors, with a separate control system for each, is necessarily more efficient or even presents a weight saving due to the lack of a differential. In fact, Mitsubishi's first MIEV did use in-wheel motors.

By the way, how can you connect the motors in series if you need them to run at different speeds when turning corners?

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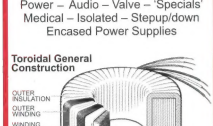

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Will existing phone equipment work with the NBN?

After reading the February 2011 Publisher's Letter, I was glad he is mellowing towards old technology and appreciating it for what it is. This is quite a change to the earlier days of "Silicon Chip will never publish a valve amplifier" or anything else valve-related for that matter.

Your mention of vintage phones brings me to my first point. How about a project to convert decadic dialling to DTMF? Such devices are or have been available commercially. One example is the "Dialgizmo" at **www.dialgizmo.com**

Unfortunately, it appears that their website is the only thing that still exists and it's no longer possible to buy the converter. Then there's the "Rotatone" **www.oldphoneworks.com/rotatone-pulse-to-tone-converter.html**

The limitation with this is that it has to be fitted inside the phone, detracting from originality. And it has to be fitted to every phone that one wants to dial from, unlike one Dialgizmo for the whole house.

As the NBN is likely to be forced upon us and since it will be DTMF only, this will present a problem to those of us who make calls from decadic dialling telephones. While I have toyed around with the idea of using 4017s to count dial pulses and a DTMF encoding chip, and will probably go down this path, I'm sure there's a more elegant one-chip solution. Obviously, if such a project was presented it would require the usual "not approved for Telstra connection" disclaimers.

Still on the subject of electronic antiquities, I notice a preoccupation of late in the Vintage Radio articles with mains leads and their connections to vintage equipment. Having worked on hundreds of valve radios and televisions, I have yet to see a problem with a knot in the mains cable being used for strain relief. In fact, I've used this method for years in many of my valve and non-valve projects without any ill effect.

Then, there was a couple of months ago a rather over-engineered earth connection to the chassis. I have yet to see any wires soldered to a chassis come off.

Incidentally, if it's one of my radio or TV sets and it had a twin-flex mains cord to start with, that's what goes back on; complete with knot too, just to annoy the Nanny State! The earthing obsession almost verges on paranoia with the inference that every old radio is going to bite you with a chassis live at 230V, unless you earth it and more importantly, are using the "approved" combination of lugs, nuts, bolts and washers. If one is that paranoid, then

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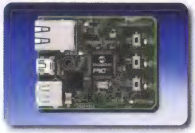

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Mailbag: continued

Comment on transformer earthing in Mains Moderator

With regard to the Mains Moderator project in the March 2011 issue, having a background in manufacturing electrical/electronic equipment and having it tested before sale, I feel I am in a position to advise you that the details of how to earth the transformer as shown in the project are incorrect.

In fact you would not need to earth the transformer at all if you were to use insulating bolts but as you are using conductive screws the screws and the transformer must be earthed. The rules state somewhere that the earth connection cannot be the assembly screw unless the earth connection is bolted to the transformer first and then you can use the protruding bolt to attach the transformer to the case. A star washer is also advisable between the earth lug and the transformer.

Another trick often used is to cut the transformer mounting lug so that it leaves a strip 3/16-inch or 1/4-inch wide to use as a quick connect lug to connect the earth cable to.

John Chappell,
Caloundra, Qld.

Comment: we were aware that we could have used Nylon screws and washers however we were not confident that they would hold the transformer securely in the event that the unit was dropped.

run your radios via an RCD plug or isolating transformer.

Finally, we come to using a chassis with no cabinet. Out in the real world, this is exactly how most home-made valve projects are built and used, and will continue to be used, earthed or not, and with or without a knot in the mains cord. One does not put fingers under the chassis in the same way one does not put fingers in a light socket.

Perhaps more emphasis should be placed on fusing the mains supply. This can be done with an in-line fuseholder to save disfiguring the chassis.

Many power transformers have been needlessly burnt out when rectifiers or electrolytic capacitors fail. For a typical valve radio, a 500mA time delay fuse works well.

John Hunter,
Hazelbrook, NSW.

Comment: we will consider the idea of a decadic to DTMF dialler but we are not sure whether any existing fixed-line phone, cordless, decadic, DTMF or whatever, will work with the NBN. At the very least, an NBN converter/adaptor would need to provide the normal DC phone line voltages as well as the 70VAC (or thereabouts) ring voltages. Will they do it? Perhaps not. With the way this NBN monstrosity is panning out, it would be no surprise if all existing fixed line phones become obsolete. That probably applies to all the other devices connected to copper phone lines.

In the meantime, if you want to use an "olde-worlde" phone, there is nothing to stop you dialling out with a small pushbutton (DTMF) phone, and then continuing the call with your Bakelite treasure.

As far as vintage radios are concerned, it is true that a knotted cord was usually the only form of anchorage and that was deemed to be safe enough. However, like it or not, no electronic equipment can be manufactured in that way today and have any hope of safety approval. SILICON CHIP is merely reflecting the reality of official regulations.

Your suggestion of operating a vintage radio set with an RCD also reflects new regulations. They are required in all homes today. In any case, most power cords in vintage radios should be replaced as a matter of course.

Enthusiastic reception for Maximite

I read the article on the Maximite microcomputer in the March 2011 issue with great interest. It is a great project and I will certainly be building one. As an oldie who "cut his teeth" on both the Commodore VIC-20 and then

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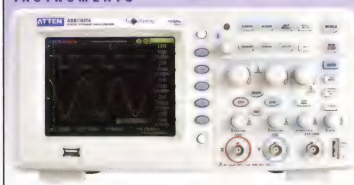

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the Commodore 64, it is refreshing to see a retro-type project; it almost brings tears to my eyes!

I bought a graphics cartridge for the VIC-20 and a 28k memory expansion card (made by "cottage industries" back in those days) and boy, wasn't I in computer heaven! State of the art stuff! I wrote a program showing Voyager's approach to Saturn, with my big chunky picture of Saturn getting bigger frame by frame as the spacecraft approached. I was really proud of that but I think it got sold with the VIC when I upgraded to the Commodore 64. I do remember it was stored on cassette tape!

Anyway, the Maximite can be used as a microcontroller as well, of course. It is indeed truly versatile and I agree with the author that it should develop its own fan base of users.

As I say, a truly great project. I bet it won't run classic games like "Raid on Bungling Bay", "Choplifter" and "Rescue on Fractalus", however. Still, if I want to fully immerse myself in nostalgia, I'll bet I can find Commodore 64s on eBay.

I look forward to constructing the Maximite.

George Green,
Wollongong, NSW.

Maximite is appetising

Congratulations on publishing the Maximite computer project. Amazing! This device could form the basis for many projects to be published in the future.

How about a complete weather station? Place the Maximite in the house next to the computer, use 1-wire temperature sensors in the rooms of the house. Use the CAN bus to connect to a weather box in the garden, measuring temperature, humidity and barometric pressure. Above the weather box measure rainfall, wind speed and direction, solar insolation, lightning and anything else I may have missed. These add ons-could be published over several months.

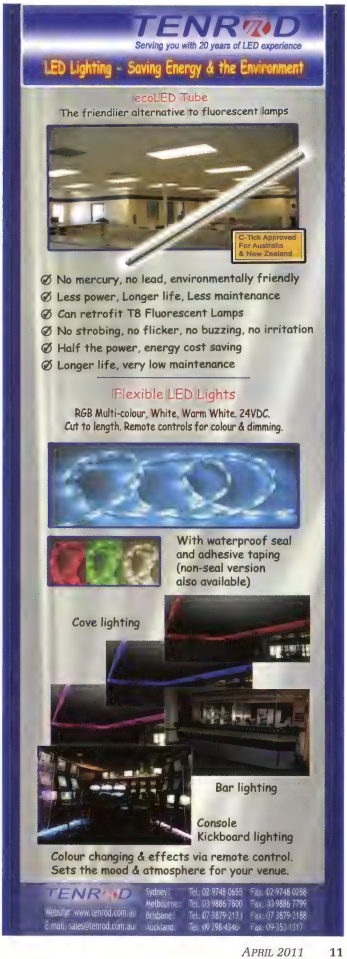
Maybe a title generator for ATV or a controller for a pool pump, with temperature logging, chlorine dosing and pH control. Fantastic!

Steve Dyer,
Carrara Qld.

Don't underestimate 8-bit micros

In the article on the PIC32 microcontroller (March 2011), I was somewhat amused to read that calculating the local sunrise and sunset was "beyond the practical capacity of an 8-bit chip". 30 years ago I wrote a program to calculate the azimuth and altitude of the planets for an Ohio Superboard. The Superboard had 10KB of ROM for the O/S and BASIC interpreter, 4KB of RAM and a 6502 CPU running at 1MHz. The program requested the user to input the time and their location, and it output the position of the planets after a few seconds of computation. The calculations for sunrise and sunset are very similar and require about the same resources.

Most of the RAM was used for the program but for a dedicated task this would be moved into the ROM.



Mailbag: continued

Digital control of valve amplifier not worth the effort

I'm writing in response to Paul Matthews' letter in the February 2011 issue, on adding digital control to a valve guitar amplifier.

I have built, modified and repaired many tube guitar amplifiers and preamps over the last 12 years or so. About nine years ago I had an interest in constructing a digitally-controlled tube preamp, having just completed my studies in electronics at TAFE at the time. Ironically, my principal inspiration for the project was the same Mesa Boogie Triaxis preamp that Paul mentions, including the novel method of controlling the various parameters of gain/bass/mid/treble/level using dual-element LDRs.

I managed to work my way through about 60% of the coding for the PIC microcontroller before I came to the conclusion that such a project would be far too expensive to be practical.

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The cost of developing and building such a device from the ground up outweighed the purchase price of the equivalent commercial preamp. I ended up completing the preamp project but opted to leave out the programmable control system for plain-vanilla potentiometer controls and a simple 2-channel switchable clean/dirty preamp configuration.

In retrospect, I simply had no real need for such programmability – a couple of sounds served my purposes adequately; anything else in between I could get using external pedals or adjusting the guitar's volume pot.

The other hurdle is trying to find a system of controlling the signal that can withstand the large voltage swings present in tube amplifiers. As Paul mentions, digital pot ICs are hard to come by in the correct values (guitar amplifiers typically utilise resistances up to 1MΩ), however most will only tolerate a handful of volts across the resistive element.

Control feed-through from the IC's data interface (known as "zipper noise") can also cause headaches in a high-gain, high-impedance analog circuit. Mesa Boogie's solution in the Triaxis is elegant if somewhat complicated (the dual element LDR is hard to come by and driving the unit requires considerable circuitry overhead). Another possible idea is to use relay-driven stepped resistive attenuators, although the physical size of such an assembly may make full implementation into an amplifier impractical.

Paul may also be interested to know of some other programmable control systems used in some commercially available guitar high-voltage tube preamps.

First, US-based Soldano created their X99 preamp utilising stepper motor-driven pots in the late 1980s and early 1990s. The system had one set of controls (gain/bass/mid/treble/level) that could be manually rotated to their desired setting and their position stored into memory for instant recall. The pots themselves were dual-gang, one track controlling the audio path, the other track acting as the positional feedback to the CPU.

The preamp itself could be reconfigured using optoisolators to add or remove triode stages and other frequency-shaping components (eg, cathode bypass capacitors), giving the preamp the ability to produce a variety of clean and distorted tones. The novelty of watching the knobs magically rotate to the appropriate positions as stored presets were recalled was not lost on many people.

The gain and tone variables in Marshall's JMP-1 preamp were controlled and stored digitally, the control elements themselves being digital resistor ICs (TC9176, TC9170). Marshall's solution to the low voltage tolerance of the digi-pot was to attenuate the signal between the tube output and the IC, performing the necessary "sound-shaping" at a lower level before passing the signal on to the next tube stage.

ADA's MP-1 MIDI tube preamp used a mixture of digi-pots (as for the JMP-1, above) and Mesa Boogie's dual-element LDR (as in the Triaxis).

Finally, American folk-rocker Neil Young had an amplifier controller made for him, affectionately known as "The Whizzer". The device, fitted with a number of servo-motors, sat on top of his amplifier in concert and would physically rotate each knob to a predefined position in response to a remote foot-switch controller, giving him the ability to quickly change sounds on his vintage single-channel amplifier on the fly.

Andrew Curtis,
Claremont, Tasmania.

The 16KB ROM and 2KB RAM of the 18F4550 microcontroller would handle it with ease. The original program used 32-bit floating point numbers and this was entirely adequate; the imprecision in results was mainly in the outer planets due to ignoring planetary interaction. For the inner planets, the results were accurate to a few seconds of arc. Unless the sunrise/sunset calculations needed to be accurate to the second, it would not need anything more complex.

I agree that modern programming is

geared more to results than efficiency and this is generally the best way to go. The planet program was written to be compact and would be quite difficult to follow without the accompanying documentation.

Today it is easy to dismiss the 8-bit processor as being quite limited but this is a relative view. They are faster than the early mainframes that were the backbone of corporate computing in the 1960s. The first mainframe I worked on was an IBM 360-30 with some instruction times measured in hundreds of microseconds and memory access was two microseconds. It did accounting and payroll for a major company. The practical capacity of an 8-bit chip should not be underestimated.

Alan Cashin,
Islington, NSW.

Deja vu with the Mains Moderator

Your Mains Moderator project to tame mains voltage excursions and Bruce Bowman's letter of woe from the ACT (SILICON CHIP, March 2011) gave me a sense of deja vu. I moved into the Ainslie area I believe Bruce is referring to some 30 years ago and about 25 years ago at the dawn of the PC era I was in a similar position to his.

I ran a calibrated HP logging voltmeter that I had access to for about two weeks. The lowest voltage was over 240V and highest over 254V; high but just under the 256V upper limit allowed under the standards at that time and fatal to nominal 230V power supplies. Ainslie is a much older area of Canberra and 1930's distribution capacity was stretched by customer demands of the 1980s and probably remains so to this day.

The supply providers' solution was to tap up residential supply voltages to reduce line losses without upgrading infrastructure and maintain the lower voltage limit at the end of distribution lines, exceeding their original distribution capacity. As I recall, I was two or three poles from a transformer. This was a problem in winter when heating loads became evident.

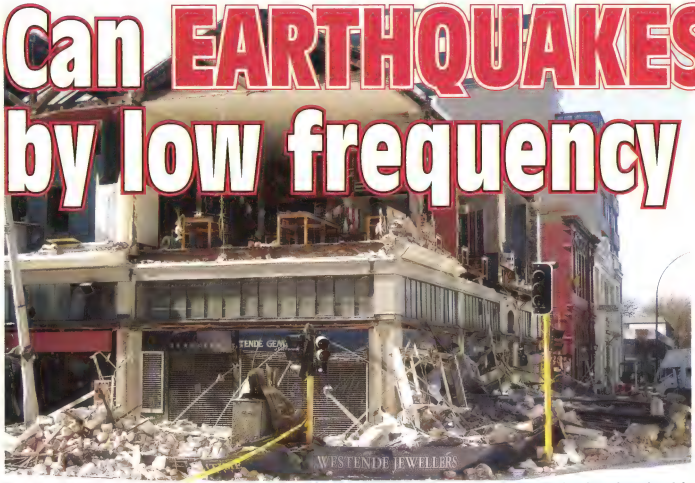
Supply authorities had a view that under-rated equipment was your problem. But that is what approval schemes were for, so how did approvals miss equipment failure at the upper end of supply voltage standards? My problem was the demise of two monitors with dead power supplies.

My solution was to built an almost identical device to that described in your article. The only circuit difference was the use of a 300V or 400V surge suppressor and no neon indicator. I used it to protect all of my computer equipment when $1000 got you a clone with a 20MB hard drive.

As an aside, I recall some B&W Pye TV sets had provision for a line-dropping resistor (5W or 10W) to be installed between its power switch and transformer primary winding for sets sold in WA, to reduce the local 260V mains supply to usable levels.

Brendan Falvey,
Gundaroo, NSW. SC

Can EARTHQUAKES by low frequency



The 2010 Christchurch earthquake. (Photo: http://rebuilding-christchurch.wordpress.com/2010/09/07/rebuilding-christchurch/)

Do low frequency radio signal variations provide a clue to the onset of an earthquake? There are no ready answers but it's tempting to investigate. This article gives some of the background and suggests how you can monitor low frequency radio signals using a simple preamp circuit feeding the sound-card input on your computer.

Although seemingly a modern nightmare, earthquakes have always been a fact of life. Every year, several deadly 8-8.9, scores of 7-7.9, hundreds of 6-6.9 and thousands of 5-5.9 magnitude quakes strike around the globe.

The Richter scale is logarithmic, so a magnitude 7 quake has a shaking amplitude 10 times greater than a 6. Further damage and deaths often result from the quake's aftermath.

Most fatalities in the offshore Indian Ocean Boxing Day 2004 earthquake (magnitude 9.2) were not caused by the earthquake itself but were Tsunami-related. Deaths can run to hundreds of thousands but damage and casualties vary enormously, often relating to population densities, building techniques, terrain and soils – or sheer luck and timing.

In 2010 the devastating January 12th Haitian and Canterbury's (NZ) early morning 4th September quakes were of similar (7.1) magnitude but casualties of some 250,000 in Haiti contrasted with none in Christchurch.

However on February 22nd 2011, a close and shallow 6.3 "aftershock" struck Christchurch at lunch time, killing hundreds and causing devastating damage.

Precursors

It's only in recent times that it has been realised earthquakes arise from the earth's tectonic plates pushing and sliding against each other. Although their cause may be now known, and seismic monitoring well established, a recent TV Horizon documentary titled "Why Can't We Predict Earthquakes" (broadcast on SBS on January 24th 2011), lamented that earthquake prediction remains agonisingly elusive.

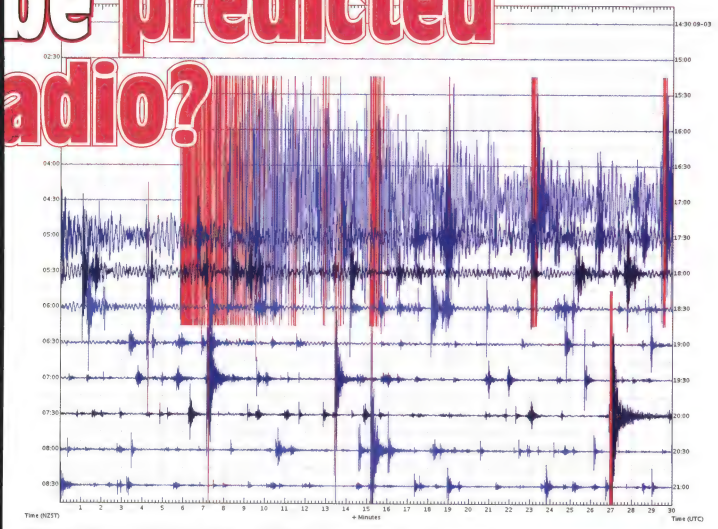
Folklore links likely earthquakes to birds showing strange behaviour, well levels suddenly changing, flashes in the night sky, rainbow clouds, lunar-induced seismic tides, sunspots, "earthquake weather", gravity waves, radon gas seepage, the onset of headaches and even (predictably) conspiracy theories and electro-magnetic weapons.

The danger that false alarms, arising

be predicted

adio?

By Stan Swan



This seismogram, recorded by the McQueen's Valley seismograph on Banks Peninsula (courtesy www.geonet.org.nz), displays the September 4 magnitude 7.1 Christchurch earthquake and some of its early aftershocks. The seismogram is coloured red if it is clipped, ie, the largest parts of the signal are not shown. If this was not done, then a large earthquake would obscure much of the seismogram from view – so if the signal is red, the real size is larger than shown. Lots of aftershocks can be seen on this image, with some of the biggest ones appearing out of the coda (dying away of shaking) of the main shock.

from such incorrect quake alerts, may eventually desensitise people has to be considered as well.

Studies have shown the pre-earthquake wandering of domestic animals, often dismissed as an urban myth, may indeed be a valid indicator. A recent Italian project showed striking toad breeding behavioural changes in the days before their (6.3) L'Aquila event of 6th April 2009. (At last – a possible use for cane toads?)

What about radio signals?

Radio propagation has long been related to solar activity and atmospherics, with the earth's charged ionosphere an especially significant factor.

In 1989 however, submarine communication monitoring first indicated seismic contributions as well, as significant signal surges were noted prior to California's October 17th Loma Prieta earthquake that year.

More recently, the French DEMETER (Detection of Electro-Magnetic Emissions Transmitted from Earthquake Regions) microsatellite (*shown at right*) detected ionospheric perturbations while passing over the September 29, 2009 Samoan and the January 12, 2010 Haitian earthquakes.

DEMETER findings in-

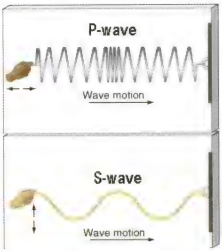
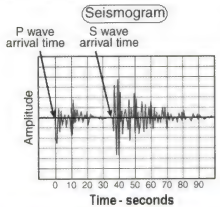


Fig.1 (above): the initial P-wave shock, akin to a longitudinal impulse along a slinky spring, travels at some 8 km/second but the more destructive sideways S-waves travel at only half this speed.

Fig.2 (below): this sample seismogram reveals a ~38 second delay between them (relating to quite a distant earthquake) – perhaps just enough time to scramble to safety?



dicate that shallow earthquakes, of magnitude 4.8 and larger occuring at night, show an associated decrease in natural EM radiation at around 3kHz. No changes were observed for deep quakes or for those that occur in the daytime.

Although the disturbances were extremely small and only revealed statistically, this study demonstrated that seismic activity may also influence the ionosphere, with the effect perceptible at even the Low Earth Orbital (LEO) satellite altitude of some 700km *before* some earthquakes occur.

P-wave earthquake alerts

Aside from EM alert possibilities, it's actually already feasible to have very short advance warning of an earthquake by detecting the initial non-destructive P-wave (P = primary, push or pressure) compressions.

These initial seismic waves travel more quickly through the Earth's crust than the destructive "S" (secondary, shear or shake) transverse waves and subsequent rolling Rayleigh surface waves.

P-waves, which are typically felt by humans as a bang or thump, travel at some 8km a second in dense earth (about twice the speed of S-waves), so advance warnings of perhaps seconds (for local rumbles) or up to about a minute (for deep or more distant quakes) may be possible.

The effect is rather akin to seeing a lightning flash and hearing thunder some time later.

A smoke alarm-sized P-wave seismic alert device already is widely marketed, especially in California (see www.earthquakealert.com).

As radio waves travel near instantly, it may be feasible to use such a device to "beat the P-wave" and radio ahead an alert by cell phone.

Although time would be very precious indeed, even a few seconds warning may be enough to "Drop, Cover and Hold On".

Chile, which is on the Pacific's Ring Of Fire, experienced a catastrophic 8.8 quake on 27th February 2010 and is considering such a country-wide alert system.

The effectiveness of a prediction device relates to reliable P-wave detection, an acceptance that false alarms (arising from normal local ground vibrations) may occur and sufficient time to react. An alert of minutes would be much more valuable (even if less reliable), which is where very low frequency radio monitoring may assist.

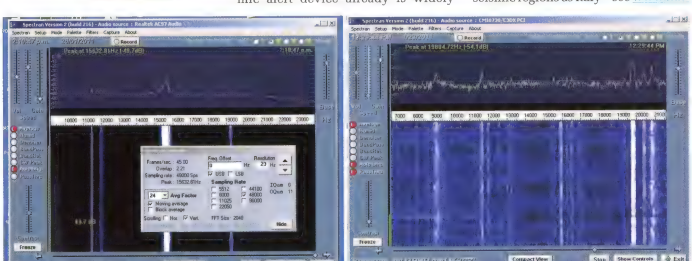
Natural radio and earthquakes

The electromagnetic spectrum is full of transient natural RF signals, many arising from the sun's activity.

The scientific jury remains out on just which, if any, are most related to earthquakes.

The basis for the possible connection plausibly relates to stressed sub-surface rock layers generating voltages and signals in the manner of piezo crystals.

Numerous accounts regarding the monitoring of different frequencies for broadband noise and static changes have been made, especially in such seismic regions as Italy – see www.nat-



Spectran displays of useful VLF signals – at left is the 15.625kHz horizontal scan of a colour TV while at right is the received signal from the Harold E Holt North West Cape (NWC) submarine communications station at Exmouth, WA. The latter is so powerful that it can usually be received throughout Australia even without a FET preamp!

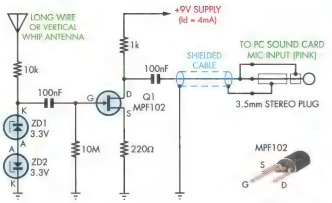


Fig.3: the circuit of a wideband preamplifier suitable for use with a PC sound card. Because the frequencies of interest are so low, virtually any antenna you can put on this will theoretically be too short – so just use what you can! A good earth would also help greatly.

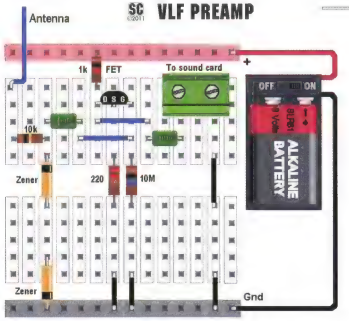


Fig.4: a suitable breadboard layout for the above preamp, drawn using "PEBBLE" (see Silicon Chip, September 2009).

About this feature:

New Zealander Stan Swan is no stranger to Silicon Chip readers, having written numerous articles over the years and is credited with introducing Australian and New Zealand readers to the PICAXE microcontroller.

Although not a resident of Christchurch and therefore not directly affected, Stan contacted us not long after the September 2010 earthquake talking about some of the work he was doing in ultra-low-frequency radio earthquake "detection".

This article is the result, written and in fact in production as the news came through about the February 21 shake.

And as we were about to go to press, on March 2 came the news that New Zealand had suffered yet another earthquake, fortunately (at 4.5) significantly lower in magnitude than Christchurch but this time located near the NZ capital city, Wellington – just across the harbour from Stan's home in Eastbourne!

Incidentally, in 1848 and 1855, Wellington suffered magnitude 7.1 and 8.0 earthquakes, the latter the largest ever recorded in New Zealand and causing considerable damage.

hazards-earth-syst-sci.net/1/99/2001/nhess-1-99-2001.pdf

A review of the literature indicates that the most promising approaches for earthquake precursors may be:
(1). Sub-Hertz and ELF magnetic transients in the .01 to 10Hz region, especially around 3Hz;
(2). VLF electromagnetic transients around 10kHz;
(3). VLF-LF broadband noise measurements in the 10 to 100kHz band;
(4). LF-MF noise and propagation in the 150kHz to 2000kHz region; and
(5). HF noise and propagation studies over 2MHz.

For our purposes, monitoring the bands between 10kHz and 100kHz are the most practical and initial investigation requires little more than a Windows PC with a working sound card – even an old clunker XP laptop with a 16-bit 48kHz sampling-rate soundcard will do nicely.

But hang on – sound cards hearing radio? Yes – quite correct! Low Radio Frequencies (RF) produce a small signal that a sound card treats just like an equivalent audio signal from a microphone. And although sound

ITU	Abbrev.	Designation	Frequency	Wavelength	Typical EM signals
0	Sub-Hz	Sub Hertz	<3Hz	>100,000km	Natural earth, ionosphere, space
1	ELF	Extremely Low Frequency	3Hz - 30Hz	100,000km to 10,000km	Deeply submerged submarines
2	SLF	Super Low Frequency	30Hz - 300Hz	10,000km to 1,000km	Sub. communication, mains grids
3	ULF	Ultra Low Frequency	300Hz - 3kHz	1,000km to 100km	Earth mode comms. – mine radio
4	VLF	Very Low Frequency	3kHz - 30kHz	100km to 10km	Near-surface sub. & cave radio.
5	LF	Low Frequency	30kHz - 300kHz	10km to 1km	Long Wave radio, aircraft beacons
6	MF	Medium Frequency	300kHz - 3000kHz	1km to 100m	Medium Wave AM broadcasting
7	HF	High Frequency	3MHz - 30MHz	100m to 10m	Short Wave radio, maritime, amateur
8	VHF	Very High Frequency	30MHz - 300MHz	10m to 1m	FM radio, TV, aircraft & marine
9	UHF	Ultra High frequency	300MHz - 3000MHz	1m to 10cm	TV, cell phones, 2-way, WiFi, GPS
10	SHF	Super High Frequency	3GHz - 30GHz	10cm to 1cm	Radar, satellite TV, microwave comms.
11	EHF	Extremely High Frequency	30GHz - 300GHz	1cm to 1mm	Radio astronomy, microwave links

The electromagnetic spectrum from "DC to Daylight" (well, almost). The bands/frequencies above 300kHz are pretty much understood but it's those below – and far below – which we are interested in here.

The Richter Scale: *not any more, it's now the Moment Magnitude Scale*

The Richter magnitude scale, also known as the local magnitude (ML) scale, assigns a single number to quantify the amount of seismic energy released by an earthquake.

It is a base-10 logarithmic scale obtained by calculating the logarithm of the combined horizontal amplitude (shaking amplitude) of the largest displacement from zero on a particular type of seismometer (Wood–Anderson torsion).

So, for example, an earthquake that measures 5.0 on the Richter scale has a shaking amplitude 10 times larger than one that measures 4.0. The effective upper limit of measurement for local magnitude ML is just below 9 for local magnitudes and just below 10 for moment magnitude when applied to large earthquakes.

The Richter scale has been superseded by the moment magnitude scale, which is calibrated to give generally similar values for medium-sized earthquakes (magnitudes between 3 and 7).

Unlike the Richter scale, the moment magnitude scale reports a fundamental property of the earthquake derived from instrument data, rather than reporting instrument data which is not always comparable across earthquakes, and does not saturate in the high-magnitude range.

Since the Moment Magnitude scale generally yields very similar results to the Richter scale, magnitudes of earthquakes reported in the mass media are usually reported without indicating which scale is being used.

The energy release of an earthquake, which closely correlates to its destructive power, scales with the 1.5 power of the shaking amplitude. Thus, a difference in magnitude of 1.0 is equivalent to a factor of 31.6 (= $(10^{1.0})^{(1.5)}$) in the energy released; a difference in magnitude of 2.0 is equivalent to a factor of 1000 (= $(10^{2.0})^{(1.5)}$) in the energy released.

Richter magnitudes	Description	Earthquake effects	Frequency of occurrence
Less than 2.0	Micro	Micro earthquakes, not felt.	About 8000 per day
2.0–2.9	Minor	Generally not felt, but recorded.	About 1000 per day
3.0–3.9	Minor	Often felt, but rarely causes damage.	49,000 per year (est.)
4.0–4.9	Light	Noticeable shaking of indoor items, rattling noises. Significant damage unlikely.	6200 per year (est.)
5.0–5.9	Moderate	Can cause major damage to poorly constructed buildings over small regions. At most slight damage to well-designed buildings.	800 per year
6.0–6.9	Strong	Can be destructive in areas up to about 160km (100 miles) across in populated areas.	120 per year
7.0–7.9	Major	Can cause serious damage over larger areas.	18 per year
8.0–8.9	Great	Can cause serious damage in areas several hundred miles across.	1 per year
9.0–9.9	Great	Devastating in areas several thousand miles across.	1 per 20 years
10.0+	Epic	Never recorded in human history.	Extremely rare (unknown)

Courtesy Wikipedia – http://en.wikipedia.org/wiki/Richter_magnitude_scale

cards typically only handle signals up to around 24kHz this is quite adequate for this purpose.

Just to clear up a confusion which often occurs: why can't you hear low-frequency radio signals?

Even though they may be in the audio frequency range, you can not hear low-frequency radio waves as they're an electrical rather than acoustic phenomena. Your ears cannot "detect" radio signals.

Software

Many specialised and complicated panoramic display sound card Windows programs are freely available, but it's recommended you start with simple ones to get a feel for things. The tiny SAQrx (https://sites.google.com/site/sm6lkm/saqrx) should cope well, although Spectran (www.weaksignals.com) is better suited for more demanding work.

Once installed, verify operation by whistling into the computer's mike to observe the resulting spectrogram. A valuable waterfall display option (plotting frequency versus time) is included in Spectran – it can be set to scroll sideways with a left mouse button click.

This waterfall can be a visual goldmine when following transient signals, as they remain on screen long after they've ceased. It can be fascinating to "see" the spectrum of such everyday sounds as music, speech and bird calls!

An averaging option allows masking out of random noise to better show weak transmissions, and recordings can be saved to hard disk. More professional soundcard display offerings, especially the Spectrum Lab (http://dl4yhf.ssl7.com/spectra1.html), may suit once you are familiar with the panoramic technology.

Apart from the PC, the only other hardware required to initially "hear" the nearby EM spectrum is a suitable 3.5mm phone plug (usually mono) and a short length of wire! Wavelengths at VLF are so long almost any handy length of insulated wire will do. Run the wire vertically if possible, and ensure it doesn't snag or short to anything lively or your computer sound card may be damaged.

Wind it in during any likely thunderstorms as well, as it could present a hazard to you and your computer.

Performance

In a typical built-up area mains noises (50Hz and harmonics) will promptly show themselves to indicate "receiver" operation but a more useful beacon can be the 15.625kHz horizontal scan oscillator of a PAL colour CRT TV set. This can usually be detected from many metres away. Assorted spu-

rious signals may also be seen arising from normal PC operation. Removing the sound card input plug will verify the true nature of such "ghosts".

My urban location here in remote NZ meant other VLF transmissions were initially only weakly detected, although these were revealed better in quieter areas using a battery powered laptop and long wire antenna positioned well away from mains wiring.

Readers living closer to powerful VLF submarine stations may find even a short hookup wire antenna will do!

Other low frequency "noise"

Aside from man-made noise, VLF reception may be further complicated by day/night variations and extensive tropical storms.

Across the globe, lightning strikes almost continually (refer the World Wide Lightning Locator Network at http://webflash.ess.washington.edu) and it's long been known that the violent electrical discharge may also even propagate upwards from storm clouds and influence the ionosphere.

So-called "Schumann resonances" may then arise, caused by a lightning-excited approximate 8Hz resonance in the waveguide cavity formed by the earth's surface and the ionosphere.

The bouncing EM pulses associated with such powerful lightning pulses and the resulting atmospherics ("spherics") may propagate globally on low RF frequencies, to be heard as static crashes and even gliding frequency whistles and chirps.

An auroral display may also produce such effects – listening to such atmospheric music can be part of the fun!

Enhancement

Given the very low frequency nature of the signals almost any simple pre-amplifier may be used to boost the input to the sound card.

A complete receiver (such as the well known BBB-4 – www.auroral-chorus.com/bbb4rx3.htm) could even be constructed for standalone listening but this would lack the panoramic display and recording features that PC monitoring allows.

As broad-band low frequency boosting is needed, tuned circuits are not utilised, although a suitable low pass filter may be needed to block any nearby powerful AM radio stations.

After considering various low-noise opamps, a simple general-purpose MPF102 N-channel J-FET was eventually used – see Fig.3. Layout and component values are not critical.

This setup, powered by a 9V battery performed very well, revealing signals that were previously buried in the noise.

The two back-to-back 3.3V zener diodes ensure any larger voltages on the antenna will be shorted to earth. The circuit draws around 4mA and can be easily assembled and enclosed in a small metal case to give shielding. Leads to the sound card should be shielded to reduce mains pick-up.

Suggested monitoring approach

Launching VLF monitoring satellites or erecting gigantic antenna farms, such as the military use, is naturally a tad daunting.

Powerful VLF submarine communication transmitters conveniently already blanket the world so it's suggested that initial monitoring merely follows the approach of simply checking their VLF signal strengths over an extended period.

However, sudden variations may well arise due to solar storms (see www.swpc.noaa.gov) or the VLF site's transmitting activity. Northwest Cape wasn't set up just for your listening pleasure!

Once the sound card-based equipment is organised at your location, use a stable set up and antenna so any on-screen changes will be noticeable.

To help gain initial experience perhaps refer to your displays (and recordings?) when an earthquake has occurred somewhere, to see if unusual VLF activity was associated with transmitters near it.

Details of the world's latest earthquakes are soberingly shown at http://earthquake.usgs.gov/earthquakes/recenteqsww/

Conclusion

Don't expect instant answers in the VLF monitoring quest, as display checking may be akin to watching paint dry.

Opinions may differ and findings are uncertain but seismic scientists worldwide earnestly scrutinise such displays in attempts to see if seismic and low-frequency radio signals act as possible earthquake precursors.

It may well be a false quest, with no more pre rumble significance than the birds going quiet, your dog hiding under the bed – or the cane toads pausing their advances.

But there just may be something in it – and your simple setup could help provide a valuable key or stimulate further investigations!

References, extensions, published scientific studies and quoted web sites are conveniently linked via a resource site at www.manuka.orcon.net.nz/eqradio.htm

SC

A typical published account

Title: Geomagnetic precursors of intensive earthquakes in the 0.02 to 1Hz frequency range of geomagnetic pulsations – abstract only. Corporate Source: Joint Publications Research Service, Arlington, VA.

During intensive geo-tectonic processes such as earthquakes, pulsations are observed in the geomagnetic field at a frequency of 0.02 to 1Hz with anomalously high amplitudes. These pulsations usually appear as beat phenomena lasting from several minutes to several hours. It has been found that the pulsations are excited only in magnetic components of the terrestrial electromagnetic field. The periods and amplitudes of the pulsations are nonlinearly related to the intensity of the earthquakes. Pulsations of this type are not observed when earthquakes do not occur. Additional analysis shows that frequently the pulsations precede intensive earthquakes by 10 to 200 minutes, then drop for about 1 hour, then appear once again during the actual earthquake. Oscillograms of such pulsations are presented. The periods and amplitudes of the geomagnetic pulsations preceding earthquakes are found to be linearly related to the magnitude of the earthquakes. A regression equation relating earthquake magnitude to pulsation characteristics is presented.

Author: GOGATISHVILI, Y. M. CASI Accession No. 85N23178. Published: February 1985 **(referenced at** www.manuka.orcon.net.nz/eradio.htm**)**

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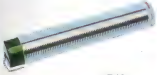

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dick smith
Talk to the Techxperts

eti The Birth of ELECTRONICS

40 years ago this month, a brash new electronics magazine burst onto the scene in Australia: Electronics Today – later called Electronics Today International or simply ETI. It really caused a stir and provided stiff competition to the long-established "bible", Electronics Australia.
Here is the story of how it began, as told by ETI's founding editor, Collyn Rivers.

AROUND JUNE 1970, newspaper adverts, for months, sought someone 'experienced in public relations and with a sound practical and theoretical understanding of electronics'.

I ignored it for a time, as that's like seeking a priest with a plumber's license (also because I'd sooner be in jail than work in PR) but I eventually advised I could write reasonably well and knew a fair bit about electronics. I also asked what the job really was.

One interviewer, Colin Ryrie, was clearly a businessman, another was Colin's son and then a young schoolboy – Kim Ryrie – electronics enthusiast and later of Fairlight Synthesiser fame.

I worked out fast that a kid in short pants had to be there for a very good reason – so attended mostly to him.

Kim asked what I thought of *Electronics Australia*, revealing that he had read it from way back (as indeed had I). He fortunately shared my view that while technically excellent, it read like Edwardian editions of Ecclesiastic Monthly (even reviewing religious gramophone records).

In essence it was instructive – but boring as

ET Vol.1, No.1 – deliberately released on April Fool's Day, 1971. It had a bright, fresh approach – just compare it to the venerable April 1971 issue of "Electronics Australia" at left!

Rise and Fall of TODAY INTERNATIONAL

sorting batshit. It seemed as if an ultra-conservative staff were unaware (or did not care) that most of its readers were 12-25 year-old dudes.

I was asked if I could produce something more readable. And if so just why I thought I could.

My background

My background is a bit unusual. I left school (and also most else) of my own choosing when I was 10 and never went back to any part of it.

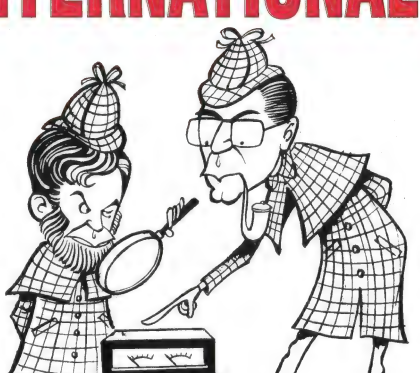
I vaguely coped until 13 or so and then spent my days building bicycle wheels rather better than most during the day, and reading anything I could get hold of at night.

Existing as I did, in WW2 London, there was also the inconvenience of things that went bang being tossed down from above. But I more or less coped. And had read my way through most of the major classics by 16.

At 17, I joined the RAF and to my genuine surprise was immediately picked and packed off to learn (ground) radar technology.

By the age of 19 I was one of only some twelve or so RAF staff running the UK's Gee (radar based) military and civilian air navigation system.

After that I did development work on guided missiles – until it sunk home that the bit up front went bang (and I'd had enough of that as a kid) – and moved to Vauxhall/Bedford's then research laboratory. From there I engineered myself into driving a big 4WD Bedford twice the length and breadth of Africa (studying road surface conditions).



There was great rivalry between the two magazines – the newcomer, *Electronics Today* and *Electronics Australia* (which had been publishing in various formats since 1922). "Sherlock" Rivers and "Holmes" Willams (then publisher and editor respectively) were immortalised in this cartoon by then EA artist Gary Lightfoot.

Great fun mostly – except persuading the French to let me drive (twice) through their bloody war in Algeria.

I eventually found my way to Australia – and that interview.

No experience, got the job!

What I basically said was that I had never edited anything before in my life but probably knew enough about

About the Author

Collyn is a primarily self-educated research engineer (following a spell as a ground radar engineer in the RAF, he worked with de Havilland Propellors on early guided missile power supplies, and then with Vauxhall/Bedford Research in the UK).

In 1970 he switched careers to become a technical writer and publisher. Following the ETI days he subsequently founded Vernon Rivers & Associates, undertaking specialised projects for companies including IBM, Wand, Hewlett Packard etc.

From 1982-1990 he was technology editor of The Bulletin and Australian Business, and later founded Caravan & Motorhome Books (www.caravanandmotorhomebooks.com) some of whose products are stocked and sold by Silicon Chip.

Distortion in amplifiers might be a hard concept to get across . . . but not for ETI. The front cover of the December 1975 simply distorted the amplifier itself!

electronics, and that I was intrigued but frankly more interested (and still am) in literature.

I stressed however, as the RAF selection process had revealed, that I thought conceptually. Also that I cared not a jot about how almost anything 'was meant to be done'.

In essence I was mad enough to do what Kim had in mind, and marginally sane enough to make it work. And that I sought almost total freedom on how I did it. In retrospect it was a sort of Goon Show meets Electronics 101.

Astonishingly, they said 'Fine' – even to my wanting to start it also in Britain a year later – which is why initial issues were Electronics Today, but my concept was Electronics Today International from the start.

Ex-NASA tracking station engineer Brian Chapman was assistant editor, and ex-Natronics' Barry Wilkinson designed and developed the essential constructional projects. Doing our own typesetting was initially union-blocked but fixed by my seeking a 40-page Fourier transform to be typeset overnight – error-free.

April Fool's Day, 1971

The first issue was published deliberately on 1st April 1971. The initial sales (about 35,000) were way behind EA but advertising poured in.

The UK issue did not work well initially, but I sent Brian over there to seek a new editor and publisher – Halvor Moorshead, who insisted (in retrospect correctly), that it had substantial local content.

A French edition failed – following editorial relations becoming so toxic that I told them to %@& ^$#-well run it themselves – and set up in Germany and Holland instead.

Meanwhile I founded Sonics (primarily electronics/music), CB Australia, Hi-Fi Review plus a few more. In 1976 the Australian edition of ETI (to our delight and total surprise) was acclaimed 'the best electronics magazine in the world' (by the Union Presse Radio Electronique Internationale).

There was also a Canadian edition and an Indonesian language edition a year later. And also an (initially pirated) Indian edition that I agreed 'not to know about' as they needed the magazine but had Buckley's chance of paying for it back then.

Working hours? What were they?

By 1975 we had our own self-contained premises in Rushcutters Bay and I was told to 'run it as you like'. I took this possibly further than the MD had in mind and, with a mixture of staff agreement/trepidation, abandoned all formal working hours. I enabled each of the (by then) seven local publications to work in whatever way seemed best for them. Which for one magazine consisted of 72-hour virtually non-stop days and nights. I preferred not to ask how they stayed awake.

Collyn Rivers and Neville Williams regularly came across each other at press functions, product launches, etc. The significance of this picture from the 1970s is that Collyn got the girl while Neville nursed his orange juice. The other person in this photo is well-known hifi writer Dennis Lingane.

At one time I found they had secreted the then out-of-funds Radio Birdman's drummer Ron Keely on the floor above – so I made him a music editor.

I instituted a routine Friday evening party – for all staff and 'selected' industry contacts. Part owner Kerry Packer paid for it all but I do not think he knew that; we somehow forgot to tell him.

A staff artist had two huge Irish wolfhounds that slept all day across the main entry. One day Packer arrived on one of his ultra rare visits – and fell over them. Both Kerry Packer and the hounds vented their respective wrath, with Kerry storming off in a steaming rage. But a few hours later an ACP courier arrived with two huge cartons of dog food.

I employed many senior female editorial and technical staff - mostly at editor and assistant editor level; simply because I'd found they were often better at doing the job – and I had long insisted on equal pay for equal work. Several were ex NASA.

We (in Australia) often covered controversial issues. I whistle-blew what North West Cape was really about (ie, an ultra low frequency system for communicating with submerged nuclear submarines). The article even included a pic of one – complete with a launching missile. It was classified material in Australia back then – but all we needed was there for the asking in the USA. We just wrote and asked for it!

That article resulted in a visit from two overly neat Americans claiming to 'ensure truth in journalism' but when asked admitted they were CIA.

They seemed not overly bright as they demanded the name of the author which was on the article anyway! He was a well known New Zealand academic – and even more improbably right wing than they.

Les Bell, originally with ETI in the UK and then Canada, introduced 'synergistic beer drinking' sessions – where readers were invited to share a schooner or three with the staff. This provided quite invaluable feedback – as long as Les and Roger Harrison remembered to write it all down sufficiently early in the evening.

I'm not sure what EA thought about all of this (maybe Leo will reveal all) but there was an immense difference in our respective cultures; we invited them across once, and my lot were virtually dumbstruck when they arrived – all in white jackets, shorts and long white socks – whilst our lot were in jeans.

Some of the more feisty female staff had for a week or two been engaged on seeing who could wear the least at work without getting fired (as if I would!) – but not on that day – we did not wish to freak the EA crew altogether. Oddly enough I got on well with EA's then editor – the late Neville Williams – but suspect he prayed at night for my soul.

Some staff were tossed by my virtual lack of rules – except getting a really good paper out on time but despite what must have seemed chaotic (and sometimes was) those for whom

This cover, from February 1975, came about as a result of a bet . . . that Collyn Rivers couldn't get The Pope onto a cover of ETI. The bet didn't specify which pope... so Gregory got the gong and Collyn pocketed the ten bucks!

Remember these?

Some ETI projects were real groundbreakers; others memorable for perhaps not-so-kind reasons!

- The **ETI-480 50/100W amp module** produced by Barry Wilkinson; it was in the kit catalogs for at least 20 years.
- The **ETI-466 300W amp module** produced by Barry Wilkinson. Believed to be the first of its kind worldwide. Pipped EA at the post. I think this was the one for which Maree Breen bent up aluminium sheets for the heatsink and sprayed them different colours.
- The **low-TID 60W amp module ETI-470** This module was the foundation of the Series 4000 stereo amp produced by Phil Waite.
- The **Series 5000 stereo components** (ETI-477 power amp and ETI-478 preamp) by David Tilbrook.
- The **ETI-488 60W amp module** featuring two nested differential feedback loops, designed by Prof. Cherry from Melbourne.
- The **Series 4000 4-way and 3-way speakers** based in Philips drivers, by David Tilbrook.
- The various **ETI Synthesiser** modules

Apart from those perennials, the following projects created a bit of a stir:

- **ETI-595 aquarium light timer** (and plant growth lamp timer . . . he, he). A Jonathan Scott project.
- **ETI-644 direct-dial modem** (featured on the front cover with a red dial-type phone). A total breach of the Telecommunications Act at the time (and consequently a breach of the Crimes Act). It started something. Basic design from the same guy who did the synthesiser.
- **ETI-1500 Discriminating Metal Detector.** Could genuinely discriminate between gold, copper and ferrous metals (in the right hands). Design from the UK, developed here by Phil Waite.

Then there were the "no use to man or beast" projects, such as:

- **ETI-1501 experimental negative ion generator.**
- **ETI-576 electromyogram** (. . . promoted as useful for biofeedback . . .).
- **ETI-1545 Galvanic Skin Response biofeedback meter.**
- **ETI-587 UFO detector** (. . . "absence of evidence is not evidence of absence!)

ETI from the competitor's view – what we thought at EA

Collyn Rivers and his staff used to wonder how their competition, Electronics Australia, viewed them. As a staff member of EA from 1967 to 1987, I can now tell him: In the early days, we hated it!

We hated virtually everything about it. We hated the staff, the magazine, the projects and the generally insouciant nature of the whole operation. We thought, "It can't succeed".

Well, of course, we weren't really being objective, were we? Obviously, it succeeded brilliantly. With hindsight, its overall style and presentation was light years ahead of Electronics Australia and we were stuck in some sort of virtual world and certainly not the real world populated by a vast number of readers who literally gulped down anything new in the world of technology and this was where ETI was "seen to be". ETI was far ahead of EA in presenting stories on the latest technology, be it electret microphones, anti-skid braking in cars, Professor Ed Cherry's world famous amplifier with nested feedback loops or whatever.

We also used to sneer at many of the projects and some of them were definitely dodgy. But others were very good and we wished we had been able to feature them. The ETI Synthesiser was world-class.

In later years, there was grudging acknowledgement that ETI was a fine magazine and that they had many features which our conservative editorial direction (I won't go into details here) did not permit.

Louis Challis' comprehensive and authoritative reviews of audio products were a notable feature and that irreverent back page, "Dregs", sending up anything and everything was obviously a hallmark of the ETI approach. Synergistic beer drinking indeed! How dare they!

Leo Simpson

it worked seemingly thrived.

By the end of 1980, ETI had become (with peak circulation of over 195,000) by far the world's largest circulation electronics monthly but the international side of the operation fell apart shortly after – when Kim Ryrie sold off the overseas editions, each to a separate buyer. I tried for a year or two to run it as before, but then concentrated on expanding associated business activities – including a successful book sales division. I also managed many of the company's other magazines.

But the international magic had gone.

I stayed with the magazines until 1981, when the then owners' disastrously produced Sydney City Monthly (with a print run of some 50,000 and sales of about 3000) virtually bankrupted the company.

My group was sold to Federal Publishing, who ran magazines competently but ultra-formally. I stayed for 91 days, but accepting my staying could not possibly work for either party, left to start my own publishing company.

ETI (in Australia) was wound up a few years later. Then, in 2001, so was EA. Leo Simpson bought the rights to both – after he founded SILICON CHIP. He now, I suspect, successfully combines some of the rigour of EA with the some of the liveliness of ETI.

Some of the editions live on. ETI UK, for example, is now Everyday Practical Electronics. A now massively-successful Indian edition (now by far the largest in the world) had its roots in that pirate edition.

Along the way many ex-ETI associates and staff prospered: Kim Ryrie followed up the ETI Synthesizer project by developing it into the world famous Fairlight unit. Projects engineer, Phil Waite founded VitalCall, one of Australia's most successful security equipment companies. ETI assistant editor Jane McKenzie became Editor of Choice magazine. And there are many many more.

I thank Leo for providing this opportunity to celebrate what would have been ETI's 40th birthday.

Also a thank you to Dick Smith (who started Dick Smith Electronics at much the same time I set up ETI), Gary Johnston of Jaycar, and Jack O'Donnell of Altronic Distributors. All assisted hugely with the constructional projects that were such a major part of the magazines. **SC**

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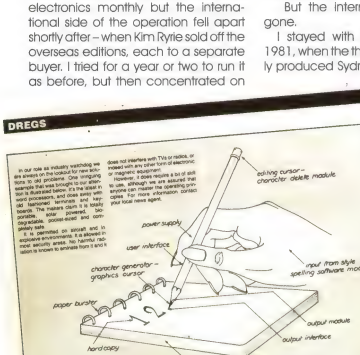


Aaah, the Dregs – who can forget this irreverent "last page" which adorned every issue of ETI from the early days. It was right up there with "Synergistic Beer Drinking" and demonstrates the flavour of the magazine. (Beer flavour?)

Off the rails

From time to time in this column, we have a little dig at the computer industry's pretentious economic nonsense; montage-stock into responsible office they got into more pretty quickly was the public power. An early glimpse of this was the transport system. Following a searching review, the lumbering state bureaucracy knows for years as "Victail" was spun off into separate divisions. Monopolistic and

As the Victorian State Government Railways was rather shortsighted to "Victail" – who not apply the same marketing strategy to the two new divisions. After all, trying to fit "Victorian Metropolitan Railways" onto the sides of carriages, advertising signs etc., presents some difficulties. Shorter words are more economical, too. Hence, the metropolitan railways are called "Metrail".

The public services units have yet to announce a title for their countries rail division.

Never give a sucker a break

Those of us who observe the ways of fundamentalist it turn out to be a viable set of economic and rules. The most basic of all is: never give a sucker an even break. In refreshing to know that in the cut-throat, dog-eat-dog capitalist world. But things are a little different in China, where they've all kinds of rules to govern business. The best policy, it seems, is to be Beijing-backed companies signed US$2.8 million to buy a 2.5% stake in Conic Ltd, makers of computers and telephones.

There were a number of motivations for the sale, it was that the Chinese wanted to prove to an increasingly jittery Hong Kong business elites that they could manage a Hong-style industry efficiently. The other major related reason was to try and prevent the steady erosion of the Hong Kong economy in 1997 and communist take-over approach.

But the poor old Chinese had reckoned without Mr Au. Alex Au was the chairman of Conic, and what we in Australia would call a "raider" as a prominent racing identity. When control of Conic was up for grabs in May, it was revealed that Alex had managed to sell his Conic stock to the consortium for US$18m, stitched them done for a handsome profit from the Conic company worth US$27.3m.

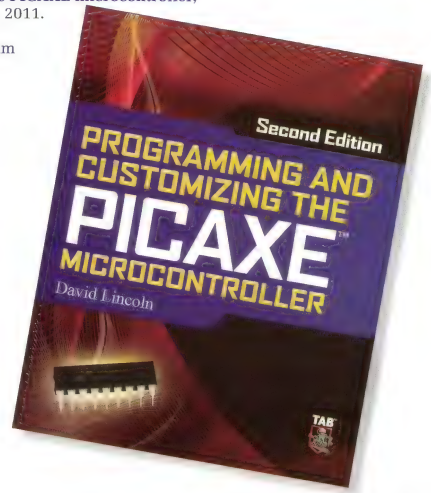
The Chinese were understandably surprised by this development. They accused Alex of overstating the company's profits, financial crimes, the carrying out of insider trading and other activities. They claimed US$68m had been lost on such activities. However, this sound familiar to the Wall Street boys downstairs, I am sure.

Mr Alex Au was heading, but we can't help but guessed. If you see a slippery-looking guy walking down the street with two heavy suitcases, take him seriously.

ERRATA

Printers feature Lucky 1984 beware: In the list of distributors given at the end of the feature, Polytel Electronics was shown correctly as distributors of the Epson LX-80 printer. However, Polytel Electronics has advised that it has no longer connection with Rod Irving Electronics or C-Tech, which are separate companies.

Programming and Customising the PICAXE microcontroller, by David Lincoln. Second edition, 2011.
Published by McGraw-Hill/TAB.
302 pages, soft covers, 187 x 234mm
ISBN 978-0-07-174554-3
Price $65.00



As a fan of David Lincoln's earlier books, I see his new 300-page text as a great aid when wrestling with applications for these popular PICAXE microcontrollers.

This upgraded second edition works at many levels, since with beginner, intermediate and advanced sections it should appeal to schools as well as being a good reference for old hands, hobbyists and -gasp- even engineers. At first glance the software-slanted style is refreshing and many novel ideas are explored but code (especially in the advanced experiments sections) is a tad sprawling.

Layout is arguably somewhat loose, and cross-referencing rather lacking. Hence the index fails to list "wireless" or "temperature", although the latter is mentioned under the DS18B20 sensor. RFID is featured but wireless link coding is considered under Radio on page 179. It's unclear if this relates to popular 433MHz (or Xbee) units however.

Many texts now come with a back cover CD or are perhaps web-linked for copy and paste downloads but past users of these PICAXE books were faced with -argh!- raw code entry.

Of course, longer programs demand online access, as typos will surely otherwise arise. I well recall pages of games code listings in early 1980's computer mags (VIC-20, Spectrum etc) that lead to keyboard angst and weary eyes.

To my dismay no mention in this second edition is made regarding code download availability but (thankfully!) fine print on the outside rear cover reveals it's hosted at www.lincsoft.com. Programs however are shown there as a single long listing and keen-eyed copy and pasting to the editor will be required.

Chapter 6 outlines some dozen schools level experiments (LED flashing and motor driving especially), while Chapter 7 has another 20 more advanced investigations relating to steppers, servos, I^2C, SPI and LCD driving. Schools would have especially benefited from a simple numbering system here, as insights flow over many pages and it's not always easy to distinguish between them.

Most experiments are based around the long-popular 08M and 18X PICAXEs but a supplement covers the modern "M2" offerings.

Wearing my photo-journalist's hat and given the A1 technology now available, at least a few pictures would have been appreciated. Only a single image (the AXE092 Schools Experimenter Board) is shown, with schematics being just simple line drawings akin to those in David's earlier "Mechatronics" and first edition booklets. Bolder images, more in the style of the Revolution Educations manuals, would have perhaps better caught the eye.

This is naturally both an initial marketing and educational end user issue; kids sweltering in classrooms during Australian heat-waves need stimulating.

Personally I'd have whipped up a bit of early can-do enthusiasm as well (photos of pre-teens robots, "girls can do anything" smart traffic lights, old codgers with balloon wireless weather telemetry etc – all with "it works" smiles) but then that's -ahem- my own style!

All up I'd say every electronics class, school and library should have a copy. Perhaps the biggest compliment I can make is that this book is one I should have perhaps rustled up myself!

(Stan Swan is the author of numerous SILICON CHIP PICAXE articles). SC

Fed up with the sound from your iPod or MP3 player?

Build this headphone amplifier and be amazed at the difference!

By NICHOLAS VINEN

IF YOU ARE USING ear buds with your iPod or MP3 player, you are getting the equivalent of sonic garbage. Nor does using a high-quality pair of headphones do much to improve it. You need to use a good-quality external headphone amplifier and a good-quality set of headphones and then you will be really travelling (riding, walking, whatever) in style.

So why put up with sonic garbage? You can have much better sound quality. The headphone amplifier described here has low noise and distortion, as well as a long battery life.

So why are these portable players so poor? While the digital-to-analog converter (DAC) in your music player may be quite good, in many cases it is let down by a feeble headphone driver. This not only limits the maximum volume but can also introduce a lot of distortion even at lower volume levels.

With an external amplifier, the headphone driver in the music player is no longer required to supply high currents into a low impedance. It only has to provide a signal voltage into a high impedance load (in this case, about 5kΩ). The external amplifier takes on the more demanding job of driving the low (and variable) impedance headphones to a sufficient power level.

There are a lot of different music players out there and it is not possible for us to try them all but from the tests we have run, it seems that the majority of even better-quality players can benefit significantly from an external amplifier such as the circuit presented here.

While various different styles of headphones and ear-buds are available, from this point on we shall simply refer to them as "headphones".

Performance comparison

To see how much of an improvement this headphone amplifier can provide, refer to Fig.1. This is a graph of total harmonic distortion and noise (THD+N) against frequency for an iRiver iHP-140 music player. This is an older model with an internal 40GB hard drive and we tested it because it has a reputation for reasonable sound quality (and we had one handy).

The red line shows the distortion from its line output. Not all portable players have a line output but if it is present, it usually provides the lowest distortion signal. As can be seen, the performance of this unit is quite good, with distortion below 0.01% up to 4kHz and 0.015% at 10kHz.

However, if we connect a load to the headphone output (to simulate headphones), the distortion is considerably higher. The green line shows the distortion into a 32Ω load and the blue line into a 16Ω load, which is considerably worse. Most ear-buds present a 16Ω impedance or thereabouts. In that case, THD+N at 1kHz is above 0.07%.

The two additional lines (mauve and pink) show the same player operating under the same conditions but this

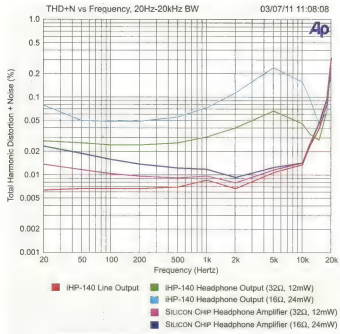


Fig.1: a comparison of the distortion from an iRiver iHP-140 MP3 player with and without our headphone amplifier, both channels driven. For both 32Ω and 16Ω loads, the distortion is lower when using our amplifier up to around 15kHz. Between 1kHz and 10kHz, the reduction in distortion with the external amplifier is dramatic, in some cases by an order of magnitude.

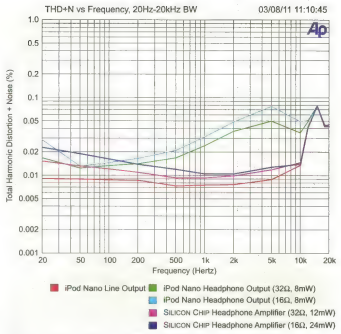


Fig.2: a comparison of the distortion from an iPod Nano 8GB with and without our headphone amplifier, both channels driven. In the case of a 32Ω load, the distortion with the external amplifier is the same or better and again the largest gains are between 1kHz and 10kHz. For 16Ω loads, the same applies except that the iPod output is slightly better between 30Hz and 120Hz.

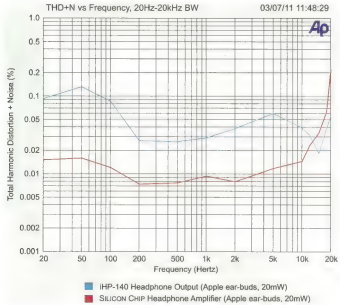


Fig.3: this shows the distortion when driving small Apple ear-buds (both channels) from the headphone driver in an MP3 player and then the distortion from the same player via our amplifier. The reduction in distortion is clear from DC up to 12kHz. Above 12kHz, the light loading on the player's output with the external amplifier allows its distortion to rise sharply (a quirk of the player).

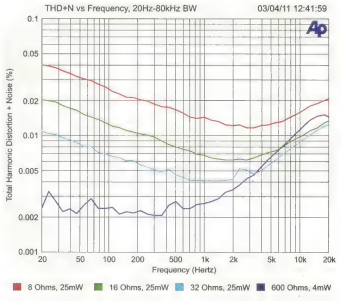


Fig.4: the Total Harmonic Distortion plus Noise (THD+N) over the audible frequency range, for our amplifier only. In the critical mid-band region of 300Hz-3kHz, the distortion is below 0.005% for 32Ω and below 0.01% for 16Ω. For higher load impedances, the performance is even better although maximum power drops. The high-frequency distortion for 600Ω rises quickly due to the high output voltage.

time the headphone amplifier has been connected between the line output and the load. As you can see, the distortion is much lower and not much worse than the line output signal by itself (which provides the lower limit). At 1kHz, the THD+N into 32Ω and 16Ω is 0.009% and 0.013% respectively – a large improvement.

These figures are worse than the those specified for the headphone amplifier because the distortion from the amplifier is being combined with the distortion from the player itself.

Also, some portable players have

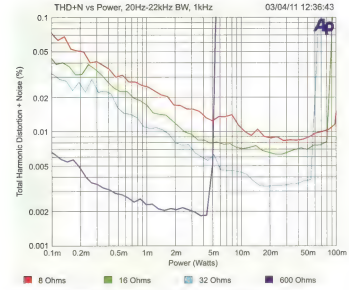


Fig.5: this graph shows the THD+N at 1kHz for common load impedances over the full power range. The distortion falls as power climbs because the rising signal amplitude swamps the noise signal. More power can be delivered into lower load impedances. Most MP3 players can only deliver up to about 20mW whereas this amplifier will deliver 60mW and more in most cases.

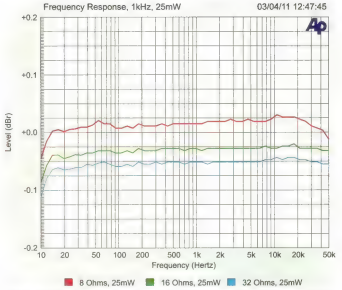


Fig.6: the frequency response for our amplifier is essentially flat over the range of audible frequencies (note the vertical scale). The 0dB voltage level was not changed for the different load impedances so this also demonstrates the low output impedance of the amplifier, ie, changing the load impedance barely has any effect on the voltage level delivered to it.

significant headphone output impedance and this can result in poor frequency response. This only occurs with specific player/headphone combinations that we don't have to test. Our headphone amplifier does not suffer from this problem since its output impedance is uniformly low (around 0.1Ω).

iPod measurements

We also made some measurements with an iPod 8GB player – see Fig.2 (the colour coding is the same as Fig.1). There are some interesting differences from Fig.1.

Firstly, we can see that the headphone driver in the iPod has less rise in distortion with a 16Ω load compared to the iRiver but it can't deliver as much power (it starts clipping at about 10mW). Also the iPod's DAC has a more sudden rise in distortion above 10kHz.

Because the iPod's distortion is relatively low below 200Hz, the summing of the distortions from it and the headphone amplifier mean our amplifier's output is slightly higher in distortion at low frequencies.

In the high-bass and the critical mid-band frequencies though (200Hz-12kHz), using the external headphone amplifier results in a big improvement in the distortion figure. At 1kHz it goes from 0.25-0.3% down to 0.009-0.011% and at 5kHz the distortion from our amplifier is about 1/5th as much. The majority of musical content exists between these frequencies so not only do you get much more output power to play with but significantly improved sound quality too.

Unfortunately the iPod's rise in distortion above 10kHz is almost entirely from the DAC or its filter so we are stuck with it, regardless of whether we use the internal or external amplifier.

We also did a simple comparison using the iRiver iHP-140 and some Apple brand ear-buds, to see what effect a reactive (rather than purely resistive) load would have on the amplifier. Resistive load testing is all very well but sometimes you need to use the real thing. As you can see from Fig.3, the measurements confirm what we expect; the external amplifier drives the ear-buds with much lower levels of distortion.

Note that the measurements at high frequencies (ie, above 10kHz) for the players do not tell the full story. This is because we have had to use a 20Hz-20kHz bandwidth due to high levels of DAC noise above 20kHz from both players. This means that the high-frequency distortion from both players is actually much worse.

Impressions

In practice, the difference in sound quality is dramatic and unmistakable. The output from our amplifier sounds much cleaner and less distorted. Bass is clean and powerful with our headphone amplifier and by comparison, distorted and weak when listening to the iRiver by itself. It isn't just at high power levels that the difference is apparent; we made measurements at 1mW (a more sensible listening level) which show just as large a disparity in performance.

In part, this improvement at low volume levels is due to the fact that virtually all MP3 players have a digital volume control. These are usually quite a bit noisier than an analog volume control (ie, potentiometer) at their lower settings, where they will be commonly used. Because our design uses a pot, the resulting signal-to-noise ratio is superior.

With the external amplifier connected and set to the appropriate gain, you can operate the player at maximum, reducing the player's contribution to both noise and distortion.

For more details on our amplifier's performance, refer to Figs.4-7.

Fig.4 shows the THD+N against frequency for common headphone load impedances. The increase in distortion at lower frequencies for lower load impedances is due to the amplifier IC's internal supply sagging under load. We presume that the 600Ω high-frequency

Specifications

	8Ω	16Ω	32Ω
THD+N* (1kHz)	0.016%	0.007%	0.004%
THD+N* (10kHz)	0.017%	0.010%	0.009%
Signal-To-Noise Ratio (unweighted, 20-20kHz)	-88dB	-91dB	-94dB
Signal-To-Noise Ratio (A-weighted)	-90dB	-93dB	-96dB
Channel separation	better than -64dB up to 5kHz		
Input impedance	5kΩ (approximately)		
Operating battery voltage	2V – 3.8V		
Current drain	15mA		
Battery life	Approximately 200 hours		

25mW, 3V Supply, 1kHz, 20Hz-80kHz Bandwidth

** Total Harmonic Distortion Plus Noise*

distortion is worse than 32Ω because of the larger voltage swing involved, exposing non-linearities in the amplifier's output stage.

Fig.5 shows THD+N for the same load impedances but this time against power output. As expected, distortion falls as power increases due to the signal level increasing while the noise level is fixed. This occurs until the onset of clipping, which is due to current limiting for low load impedances and the limited voltage swing into 600Ω.

Fig.6 shows the frequency response which is essentially flat from below 10Hz to above 50kHz (note the vertical scale!). The 0dB point was not reset when the load impedance was changed so this also illustrates the low output impedance which is around 0.1Ω.

Finally, the channel separation is also fairly respectable at better than -60dB over most of the audio spectrum.

Practicality

To be useful, the external amplifier must be small and light and have a long battery life. The battery should be cheap and easy to charge or replace. It also needs to work with virtually any headphones.

To this end, we have chosen to house it in an Altronics H0352 handheld plastic case. The complete unit measures 120 x 75 x 25mm and weighs 300g including the battery (or about 200g without the battery). It can fit in a pocket. Changing the battery is quick and easy thanks to the slide-off battery cover.

This battery consists of two AA cells which can be alkaline, dry cell, lithium or NiMH. Alkaline and lithium types give the best performance because of their higher nominal voltage. When on, the current draw is around 15mA, whether idle or delivering moderate power levels. This increases slightly at higher volume levels. A good pair of alkaline cells should last around 200 hours. As a bonus, because your player won't have to drive the headphone load, its battery should also last slightly longer.

While the driver IC is specified for 16Ω and 32Ω loads, we have found that it will drive 8Ω loads as well, provided they do not have any large impedance dips. Higher impedances are not a problem although power delivery falls to about 5mW for 600Ω (in practice that's usually enough). So it should work with virtually any headphones.

Since higher voltage operation is preferred, rechargeable alkaline cells may be a better choice than NiMH. Having said that, it will work with NiMH cells until they are quite flat (1V per cell).

In order to give some idea of the battery state, the power LED dims as the battery voltage drops. It's quite bright with fresh cells and ends with a dull glow when they are flat. The charge state at a particular brightness depends on the type of cell used but most cells are running out of puff by 1V, which is about where correct operation ceases.

Warnings

This headphone amplifier can deliver lots of power; much more than most amplifiers internal to music players. This is both a benefit and a hazard. Some players can't develop much volume with certain headphones. This may be on purpose, in an attempt to prevent hearing damage.

To give you an idea of how efficient headphones can be, they can have ratings as high as 106dB(SPL)/mW or more. **With highly compressed pop music, the kind of volume that can be produced will damage your hearing very quickly.** It can also be a problem if you put the headphones on and press play without noticing that the volume control is turned up high.

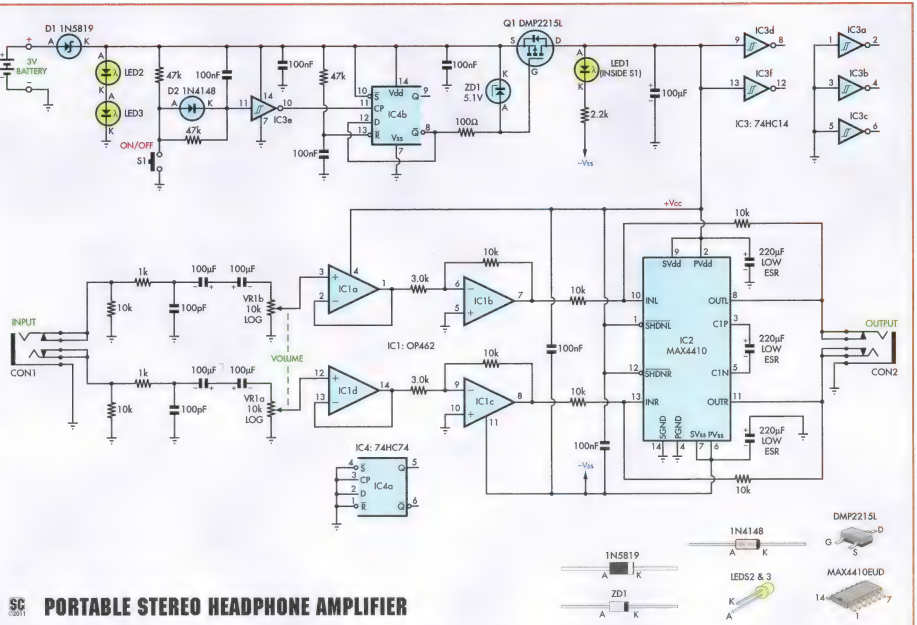
The solution to the latter problem is simple: always turn the volume down to minimum before putting the headphones on and then slowly turn it up after pressing play. Stop when you reach a comfortable volume level.

The issue of long-term hearing damage is more tricky. This is especially likely if you are often listening in noisy environments (eg, on a bus) as the temptation to turn the music up to overpower the background noise can be great. In this case, you are much better off using noise-cancelling headphones or in-ear units, to seal out as much outside noise as possible.

It's OK to listen to loud music using headphones occasionally but

TABLE 1

Sound Pressure Level	Maximum Recommended Exposure (per 24 hours)
88dBA(SPL)	4 hours
91dBA(SPL)	2 hours
94dBA(SPL)	1 hour
97dBA(SPL)	30 minutes
100dBA(SPL)	15 minutes
103dBA(SPL)	7 minutes
106dBA(SPL)	3 minutes
109dBA(SPL)	1 minute
112dBA(SPL)	30 seconds
115dBA(SPL)	15 seconds



PORTABLE STEREO HEADPHONE AMPLIFIER

Fig.7: the full circuit for the headphone amplifier. The main component is IC2 which contains both the voltage inverter & output amplifiers. IC1 buffers & amplifies the signal while VR1 is the volume control. Power is switched by Mosfet Q1 and this is controlled by D-type latch IC4b and Schmitt Trigger inverter IC3e so that pushbutton S1 toggles the power on or off.

don't make a habit of it. We find that when the audio quality is high and the frequency response is flat, there is less temptation to listen at excessive volumes in order to compensate for lack of bass or treble. In addition, the human brain adapts to the volume level being experienced and after a while even quite moderate volume levels can be adequate to hear all the details in a passage.

Table 1 shows the maximum exposure to various sound levels before permanent hearing damage is likely to occur. Hearing loss can be a real problem (as can tinnitus) so pay attention to these figures.

Note that with headphones capable of 106dB(SPL)/mW and a headphone amplifier that can deliver at least 60mW into such a load, a sound pressure level in excess of 123dB(SPL) can be achieved!

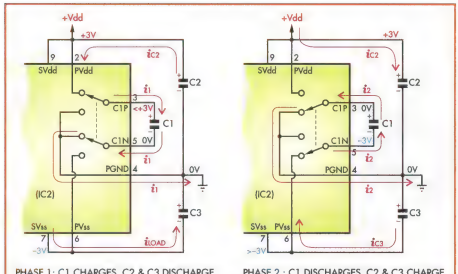


Fig.8: the MAX4410 (IC2) includes an internal switched capacitor voltage inverter. This generates a negative rail using two external capacitors (C1 & C3) plus a supply rail bypass capacitor (C2). It works by rapidly switching the connections between capacitor C1 and the supply rails (see text).

Circuit description

Refer now to Fig.7 which shows the complete circuit diagram. The heart of this circuit is IC2, the MAX4410 headphone amplifier IC. This contains the left and right-channel amplifiers, which are inverting (they share a single non-inverting input, SGND).

Each channel also has a shut-down input (pins 1 & 12, SHDNL-bar and SHDNR-bar) but since we cut power to the entire IC when the device is off, these are tied permanently to Vcc. If we had used the shut-down function instead, the batteries would not last as long in the "off" state.

IC2 contains a switched capacitor voltage inverter which generates a negative supply rail for the amplifiers. We also make use of the negative voltage it generates to power IC1, an external gain stage/buffer op amp, as well as the power indicator LED (more on that later).

This inverter is a charge pump and it allows the amplifiers to operate at twice the battery voltage. This results in good power delivery with low distortion because it allows the use of a more linear output stage. It also eliminates the need for DC-blocking capacitors at the output, which introduce distortion and also reduce bass frequency response.

Charge pump

Fig.8 shows how the charge pump operates. The circuit rapidly switches between two states, shown as Phase 1 and Phase 2. The switching frequency is around 320kHz, so each phase lasts 1s ÷ (320kHz x 2) = 1.5625µs.

During Phase 1, capacitor C1 is charged up to the supply voltage, Vdd. In this state, C1's positive terminal is connected to Vdd and its negative terminal to ground by two electronic SPDT switches. These are formed from Mosfets but we have shown them as switches for simplicity.

Some of C1's charge current is supplied by supply bypass capacitor C2 (labelled iC2) while the rest comes from Vdd. The sum of these currents is i1. It diminishes over time as the voltage across C1 approaches Vdd.

When the switch to Phase 2 occurs, C1 is disconnected from Vdd and its positive terminal is instead connected to ground. Since the charge across the capacitor remains the same, that means its negative terminal goes to -Vdd. Current then flows from C3 into C1 (iC3) charging C3 up to -Vdd while discharging C1.

The charge current for C3 isn't the only drain on C1. During Phase 2, C1 also supplies the negative supply load current for the amplifiers, from SVss. During Phase 1, this load current (iLoad) is supplied by C3, since C1 is no longer connected to SVss.

As C3's charge current during Phase 2 (iC3) must replace the current lost from C3 during Phase 1 and since i2 = iC3 + the load current, we can see that i2 represents the SVss load current during both phases. Also, i2 must equal i1 to keep the charge in C1 constant from cycle to cycle.

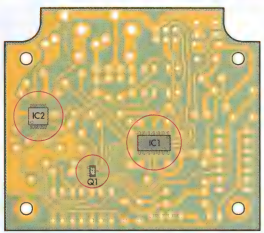
So ignoring inefficiencies (which are small), the sum of the Vdd supply currents in both phases equals the sum of the SVss load currents in both phases. This means that the negative supply current is ultimately drawn from Vdd, confirming that the law of conservation of energy still applies.

Gain and phase

Returning to the circuit of Fig.7, we see that four 10kΩ resistors are used as the feedback network for the two headphone amplifiers, giving a gain of -1. IC2 is driven by IC1b and IC1c, two sections in quad op amp IC1, an OP462. Each is configured as an inverting amplifier with a gain of -3.3 (10kΩ/3kΩ). Because the headphone driver IC also inverts the signal, the signal phase is preserved from input to output.

The series 1kΩ input resistors at the input, designed to protect IC1 from excessive input voltages (as well as forming part of the RF filter), reduce the overall gain since they act as dividers with the volume control potentiometer. So the overall maximum gain is about three (3.3 x 10 ÷ 11).

IC1a and IC1d are configured as unity-gain buffers (ie, voltage followers) and these drive the inverting amplifiers formed by IC1b and IC1c. This is necessary because the invert-



UNDERSIDE OF PCB, SHOWING SURFACEMOUNT COMPONENTS

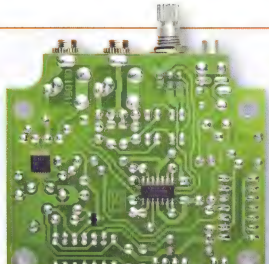


Fig.9: the three SMD components (IC1, IC2 & Mosfet Q1) are mounted on the copper side of the PCB. Use a fine-tipped soldering iron for this job & note that the two ICs are orientated in different directions.

ing amplifiers have a relatively low input impedance (3kΩ) and if this were connected directly to the volume control potentiometer, it would affect its operation quite drastically.

We chose the OP462 for a number of reasons. First, its supply voltage will vary in the range of about 3.6-6.2V, depending on the battery voltage (typically 2-3.3V). Most low-voltage op amps have a supply range of 2.7-5.5V so a specialised op amp like the OP462, with its wider range of 2.7-12V, is required. Second, there is its performance, which we have detailed in a panel later in this article.

Third, the MAX4410 data sheet states that if we are to draw current from its voltage inverter, we should draw no more than 5mA or else its distortion may increase. Quiescent current for the OP462 at 40°C and 6.2V is around 2.2mA. Then there is the current which it must drive into its loads. This is computed as follows.

Maximum undistorted power from the MAX4410 into 32Ω (60mW) is with an output voltage of around 1.4V RMS ($V^2/R = 1.4V^2 \div 32\Omega = 61.25mW$). IC1b & IC1c each deliver the same signal voltage into two 10kΩ resistors (one for their feedback and one to IC2) which in parallel form a 5kΩ load. This takes 1.4V ÷ 5kΩ = 0.28mA RMS each, or 0.56mA total.

Since IC1b and IC1c have a gain of 3.3, this means that IC1a and IC1d will be delivering a 420mV RMS signal into their 3kΩ loads for a total of 0.42V ÷ 3kΩ = 0.14mA RMS each, or 0.28mA total. So adding it all up, at maximum power into a 32Ω load, IC1 consumes a total of 3.04mA, well below IC2's limit.

Vss is also used to power LED1, via a 2.2kΩ current-limiting resistor. At maximum voltage (Vdd - Vss = 6.2V), this will draw about (6.2V - 2.0V) ÷ 2.2kΩ = 1.9mA. Taking this into account, we reach 4.94mA so we just squeak in below the limit. This is almost a worst-case figure.

Input circuitry

Signals fed to the input connector (CON1) are loaded with 10kΩ resistors in each channel, which is required for some music players (eg, certain iPods) to operate correctly. Following this is an RF filter consisting of 1kΩ series resistors and 100pF capacitors to ground. This network attenuates RF signals picked up by the input leads (although the plastic case means that some RF signals may still break through).

The left and right-channel signals are then AC-coupled using back-to-back 100µF electrolytic capacitors, effectively forming two 50µF non-polarised capacitors. This is large enough to avoid any significant low-frequency roll-off or distortion. We didn't use non-polarised capacitors because their physical size varies so much.

The signal then passes into the volume control pot, a 10kΩ dual-gang logarithmic type, and thence into the buffers and gain stages already described.

Power supply

Space is at a premium on the end panel of the case so there isn't room for a separate power switch and power indicator LED. The obvious solution is to use an illuminated toggle switch or illuminated latching pushbutton. We needed a very small unit, so we decided to use a right-angle tactile pushbutton switch with integral LED (Altronics S1179).

We must convert its momentary action to have a latching effect and with the power off, the battery drain much be zero or very close to it. This is achieved as follows.

Schottky diode D1 provides reverse polarity protection, in case the battery is put in backwards (it happens!). Its low forward voltage (about 0.23V) minimises power loss. Following D1, power for IC1 and IC2 is switched by Q1, a DMP2215L P-channel Mosfet. This was chosen because it has a very low turn-on voltage (about 1V) and a low on-resistance, minimising voltage loss and allowing enough current for IC2 to operate at high output powers.

Q1 is controlled by IC4, a dual CMOS D-type latch. This is powered directly from the battery but it consumes very little – at 25°C, it draws less than 0.1µA. IC4b is unused; IC4a controls Q1. Its role is to "remember" whether the power is currently on or off and drive Q1 appropriately. IC4 is toggled on and off by repeated presses of switch S1 which is debounced by one section of IC3, a 74C14 hex Schmitt trigger.

We use an RC filter to smooth out the button action, rejecting short bounces. It consists of two 47kΩ resis-

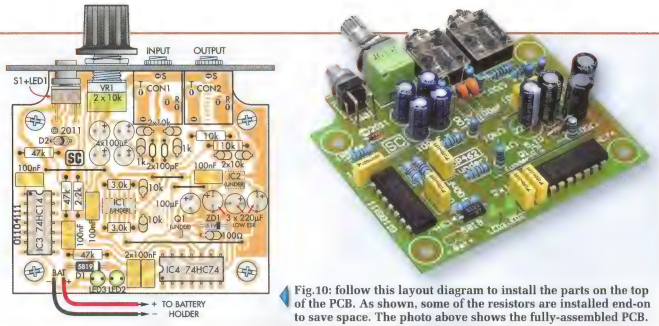


Fig.10: follow this layout diagram to install the parts on the top of the PCB. As shown, some of the resistors are installed end-on to save space. The photo above shows the fully-assembled PCB.

tors, a 100nF capacitor and a 1N4148 small-signal diode. This provides better symmetry in combination with the momentary button than a simple RC filter. When the battery is inserted, the input to IC3e is held high by the 100nF capacitor and kept discharged by the resistors and diode. Therefore, its output remains low, preventing a false button press when the battery is inserted.

When S1 is pushed, the capacitor begins to charge as current flows through the lower resistor to ground. Eventually, IC3e's output goes high. When S1 is released, a similar process occurs but in reverse, with the capacitor discharging through the upper resistor and the diode.

The result is that each press of S1 triggers a valid clock transition for IC4, toggling the latch and switching the power on or off as appropriate.

Finally, we come to LED2 and LED3. These are not included for visible effect but rather form a simple shunt regulator, akin to a 4V zener diode. This helps protect IC2 in case there is a brief spike in supply voltage above 3.6V (its maximum rating), at which point the LEDs will begin to conduct and shunt current away from it. This helps reduce the chance of damage from static electricity. The breakdown voltage for LEDs is more predictable than for a low-voltage zener diode.

Construction

All components are mounted on a single-sided PCB coded 01104111 and measuring 67 x 58.5mm. The overlay diagram for the copper side is shown in Fig.9, while Fig.10 shows the topside components.

The PCB has corner cut-outs for the box pillars. If yours doesn't already have these cut-outs then cut and file them to shape. Check that the PCB fits in the case and that the mounting holes line up with the plastic pillars. Also check the copper side for any defects such as under-etched areas or hairline cracks and repair if necessary.

Begin construction with the two surface-mount ICs (IC1 and IC2). Before unpacking them, ensure that they will not be damaged by static electricity. An anti-static mat is the best insurance against static.

Solder IC2, the MAX4410EUD, to the PCB first – see Fig.9. Find the dot on the package which indicates pin 1 and orientate it as shown. Carefully apply a small amount of solder to the upper-right pad (or upper-left if you are left-handed).

Pick up the IC with angled tweezers, melt the solder on that pad, slide the IC into position and then remove the soldering iron. If this takes more than a few seconds, stop, wait and try again.

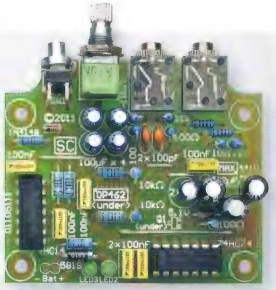
Ensure the IC is correctly lined up with its pads and centred between them. If not, wait a few seconds before melting the solder and re-positioning it. It may take several attempts to get the position and alignment right. Be careful not to get any solder on any other pins or pads.

Table 3: Capacitor Codes

Value	µF Value	IEC Code	EIA Code
100nF	0.1µF	100n	104
100pF	NA	100p	101

Table 2: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	3	47kΩ	yellow violet orange brown	yellow violet black red brown
❑	8	10kΩ	brown black orange brown	brown black black red brown
❑	2	3kΩ	orange black red brown	orange black black brown brown
❑	1	2.2kΩ	red red red brown	red red black brown brown
❑	2	1kΩ	brown black red brown	brown black black brown brown
❑	1	100Ω	brown black brown brown	brown black black black brown



The completed PCB assembly is installed inside a plastic case and is secured to integral pillars using four self-tapping screws. Take care to ensure correct polarity of the leads running to the battery compartment tabs.

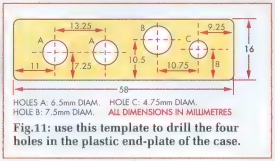


Fig.11: use this template to drill the four holes in the plastic end-plate of the case.

Once it is in place, rotate the board 180° and carefully apply a small amount of solder to the diagonally opposite pin. Re-check the orientation, as the IC may have moved slightly during this procedure and adjust if necessary.

With the IC held in place by those pins, apply solder to the others without re-melting the first two. Don't worry about bridging them, it is unavoidable. It's more important to be sure that solder has flowed fully onto all the pins and pads.

Once they have all been soldered, apply a small amount of flux paste along the pins on both sides and use fine solder wick to soak up the excess solder, a few at a time. Be careful to avoid applying too much heat during this process; wait between each session with the iron, as the tracks are very fine and can lift off the board.

As you can see from our photos, with some care this process results in a neatly-soldered IC.

IC1 goes in next, using the same approach. Alternatively, you can solder the pins individually using a fine-tipped iron as they are larger than IC2's. As before, ensure that the pin 1 dot is orientated correctly and avoid applying heat for too long.

That done, mount Q1. Its pins can be soldered individually. This is the most static sensitive of all the components so don't touch the pins. If they stick up in the air, flip the part over, but otherwise it can only go in one way.

To install Q1, place a small blob of solder on one of the pads, then heat it and slide the part into place. Re-adjust its position if necessary, until the other two pins are over their pads and then solder them one at a time. As soon as you have finished, flip the board over and fit the 5.1V zener diode as shown on Fig.10, with the indicated orientation. This helps to protect Q1 from static damage.

Through-hole components

Now for the easy part. Install the four wire links using tinned copper wire. Follow with those resistors which lie flat on the board. Use a DMM to check each value, as the colour codes can be hard to read accurately. That done, install the two remaining diodes, orientating them as shown (don't get them mixed up).

Now solder the two DIP package ICs in place. Check that the notch or dot at one end is orientated as shown on the overlay diagram. You may use sockets but they are not necessary. Following that, mount the two 3.5mm jack sockets. The edges should be parallel with the PCB; if not, enlarge one hole slightly before soldering.

Fit the two 3mm LEDs right down on the board, with the flat edge of each LED to the left. Follow with the two ceramic capacitors and the six MKT capacitors, then install the four electrolytics, Make sure that the latter are all orientated correctly. Note that one capacitor is squeezed between two others and in this case you will need

Capacitor Selection For IC2

The three 220µF low-ESR (equivalent series resistance) capacitors connected directly to IC2 are critical to obtaining good performance. The MAX4410 data sheet suggests the use of tantalum capacitors with values as low as 2.2µF.

The problem is that most through-hole tantalum capacitors have too high an ESR for good performance. This leaves us with three options: (1) use surface-mount tantalum or ceramic capacitors with low ESR; (2) find some through-hole tantalum capacitors with a guaranteed low ESR value; or (3) use low-ESR electrolytic capacitors.

We made extensive tests with various capacitors and found that the best option is to use low-ESR electrolytics. They fit in the tantalum capacitor mounting locations with a little lead-bending and the performance is consistently good. They are also quite cheap.

You need to be careful though. We bought two batches of capacitors from our local parts store, all of which were supposedly 220µF 10V low ESR. The first batch had green sleeves and gave good performance while the second batch were black and resulted in worse performance. ESR measurements of this second batch were in some cases over 1Ω so we think that these may have been regular capacitors that were accidentally placed in the low-ESR bin.

to kink its leads slightly so that it will fit upright (see photos).

Now cut or file 2mm from the end of the potentiometer shaft. This prevents the knob from sticking out too far. Avoid distorting the splines or bending the two halves drastically while doing this as it will make attaching the knob difficult.

The potentiometer and pushbutton switch can then be fitted. Ensure they are both pushed all the way down onto the board and parallel with the edge before soldering them. You may need to bend the pushbutton switch pins slightly to get it to fit.

After that, install the remaining resistors, which mount vertically, with one lead bent over. Again, check each with a DMM first.

Finally, strip 5mm from each end of two 50mm hook-up wires and twist the strands together tightly. Insert one end of the red wire through the hole marked "Bat +", then solder it to the pad and trim it. Do the same for the black wire and the hole marked "– Bat".

Fig.12: this front-panel artwork can be copied, laminated & attached to the case lid. Alternatively, you can download the artwork in PDF format from our website and print it out.

Preparing the box

Use a copy of Fig.11 as a drilling template for the panel at the end of the box (it can also be downloaded as a PDF from the SILICON CHIP website). Tape or glue it onto the panel and then drill 3mm pilot holes. Carefully expand each hole to size using a tapered reamer. Clean them up with an oversized drill bit, on both sides.

Be careful with hole placement for the on/off pushbutton The others can be made larger if necessary, as they are covered by the nuts. When ready, remove the nuts from the potentiometer and jack sockets and check that the panel fits over them.

It's a good idea to fit the potentiometer nut as it reduces the chance of damage if the unit is dropped. However, one side of the nut has to be filed down so that it doesn't interfere with the lip of the case.

To do this, first fit the pot and nut to the front panel and do the nut up

Parts List

1 PCB, code 01104111, 67 x 58.5mm
1 hand-held plastic case, 105 x 75 x 25mm (Altronics H0352)
1 2 x AA battery clip to suit case (Altronics H0355)
4 No.4 x 9mm self-tapping screws
1 front panel label, 54 x 84mm
1 10kΩ logarithmic dual-gang 9mm potentiometer
1 small knob to suit potentiometer (Altronics H6560 or similar)
2 3.5mm stereo switched PCB-mount jack sockets (CON1, CON2)
1 right-angle PCB-mount tactile switch with integral LED (S1) (Altronics S1178)
2 14-pin DIL sockets (optional – see text)
1 50mm length 0.7mm diameter tinned copper wire
1 50mm length red light-duty hook-up wire
1 50mm length black light-duty hook-up wire

Semiconductors

1 OP462GSZ quad low voltage op amp (IC1) (Element14 or DigiKey)
1 MAX4410EUD headphone driver (IC2) (Element14 or DigiKey)
1 74HC14 hex Schmitt trigger inverter (IC3)
1 74HC74 dual D-type latch (IC4)
1 DMP2215L P-channel Mosfet (Q1) (Element14 or DigiKey)
1 1N5819 1A Schottky diode (D1)
1 1N4148 small signal diode (D2)
1 5.1V zener diode (0.4W or 1.0W) (ZD1)
2 green 3mm LEDs (LED2, LED3)

Capacitors

3 220µF 10V low ESR electrolytic
5 100µF 16V electrolytic
6 100nF MKT
2 100pF ceramic (NP0/C0G)

Resistors (0.25W, 1%)

3 47kΩ	1 2.2kΩ
8 10kΩ	2 1kΩ
2 3kΩ	1 100Ω

Semiconductor Highlights: A Look At IC1, IC2 & Mosfet Q1

The high performance of this portable headphone amplifier is made possible by three special purpose devices, IC1, IC2 & Mosfet Q1.

IC1: OP462GSZ

Manufacturer	Analog Devices, Inc.
Description	Quad 15MHz Rail-to-Rail Output Op Amp
Fabrication Process	XFCB (trench isolated bipolar transistors)
Package	Small Outline Integrated Circuit (SOIC), 14 pins
Supply Voltage	2.7-12V
Quiescent Current	Typically 0.5mA per amplifier, maximum 0.7mA per amplifier
Noise	9.5nV/√(Hz) at 1kHz
Input Voltage Range	0V to Vcc-1V
Output Voltage Swing	0.065V to Vcc-0.06V (5mA)
Input Offset Voltage	Typically 45µV, maximum 325µV (800µV over full temperature range)
Input Bias Current	≤600nA
THD+N	≤0.001% (Vcc = 5V, gain = 1, Vin = 1V RMS, R_L = 10kΩ)

Comments: the OP462 has exceptional performance for a low-voltage, low-power op amp. This is the quad version; the single and dual versions are the OP162 and OP262 respectively. They are only available in surface-mount packages: SOIC, TSSOP and MSOP (in order of largest to smallest).

Most low-voltage op amps have a supply voltage range of 2.7-5.5V and are typically characterised for 2.7V and 5V supplies. With its 12V upper limit, the OP462 can run off ±5V rails as well. Its quiescent current is 0.4-0.7mA per amplifier, depending on supply voltage and temperature but is typically 0.50-0.55mA.

The noise performance is excellent for a device with such a low quiescent current. Low-current op amps don't have especially low noise voltages because they must operate their input transistors with a low collector current; this figure can't go much lower without increasing the quiescent current.

While this is a rail-to-rail output amplifier, its input common mode range only extends to 1V below the positive rail. Input voltages down to the negative rail cause no problems. For rail-to-rail output then, a small amount of gain is required (around 1.25x).

The distortion performance is excellent considering the low supply voltage and current. As with the noise performance, it is not as good as some higher power op amps but it does not rise at high audio frequencies (with a measurement bandwidth of 20Hz-20kHz), unlike many other op amps, due to its high dominant pole frequency.

The reason it can achieve this performance (and why it's quite expensive) is the XFCB fabrication technology, which places each transistor in a separate trench within the silicon die. This reduces stray capacitance between the transistors, improving high frequency performance. While this op amp is primarily intended for high-speed DC applications, it clearly works very well for audio too.

IC2: MAX4410EUD

Manufacturer	Maxim Integrated Products
Description	80mW DirectDrive Stereo Headphone Amplifier
Fabrication Process	BiCMOS (bipolar and complementary Mosfet transistors)

firmly. Mark the side of the nut that's closest to the adjacent edge, then remove the nut, place it in a vice with scrap wood on either side and file away about half its thickness from the marked edge.

You can check that it has been filed correctly by temporarily sliding the end-plate into the plastic case and placing the nut over the potentiometer hole, with the filed side against the adjacent edge of the case. If it fits then you've filed away enough material.

When finished, spray paint it black so that it blends in with the case, then push the end panel up against the PCB and do up all three nuts.

Next, take the side of the box that incorporates the battery holder and install the two battery clips. These are simply pushed into place. The part with the solder tabs goes on the side shown in our photos. If you have trouble pushing them in, a screwdriver can help but be careful not to scratch the plastic.

That done, slot the end-panel into that half of the box, so that the PCB sits on the plastic pillars. Secure it using four No.4 x 9mm self-tapping screws. Push the black wire through the hole in the solder tab which connects to the spring battery clip and solder it in place (if in doubt, refer to the photos). Bend the tab over so that it's flat against the rear of the battery holder.

Testing

Connect a DMM, set to milliamps mode, between the red wire and the battery holder. Alligator clip leads are invaluable in this situation. Insert two cells into the battery holder (if you have a bench supply, set it to output 3V with a current limit of 50mA). The initial current flow should measure 0mA (or very close to it) and the LED in the on/off pushbutton should be off.

Now press the on/off pushbutton. It should immediately light up and the current consumption should increase

Package	Thin Shrink Small Outline Package (TSSOP), 14 pins
Supply Voltage	1.8-3.6V
Quiescent Current	With 3V supply, typically 7mA, maximum 11.5mA
Input Offset Voltage	Typically 0.5mV, maximum 2.4mV
Output Power	65mW/32Ω, 80mW/16Ω, 100mW/8Ω* (3V supply)
THD+N	Typically 0.003% (1kHz, 32Ω/25mW and 16Ω/50mW)
SNR	Typically 95dB
Channel Separation	Typically 70dB
Frequency Response	DC-500kHz, +0,-0.5dB
PSRR	Typically 90dB at 1kHz
Charge pump frequency	272-368kHz (320kHz nominal)
Features	0V-referenced output, shut-down, click and pop suppression

Comments: the MAX4410 is one of the best performers among the various single-chip headphone drivers available. It also requires a fairly minimal set of external components.

Low-power speaker driver ICs used with single supplies often operate in bridge mode, driving the speakers differentially, so that no bulky DC-blocking capacitors are required for the outputs. This is not possible when driving headphones because in most cases, the two drivers share a single ground line and thus can not be driven differentially.

The MAX4410 solves this by using an internal switched capacitor voltage inverter to generate a negative rail. The analog circuitry then runs off the split supply and so its output is ground-referred. This results in lower cost, smaller size and improved performance. This also means that the analog circuitry has twice the voltage to work with, allowing for a design with more inherent negative feedback and thus lower distortion.

It also incorporates a per-channel shut-down, allowing a microcontroller to turn off the output drivers when they are not needed without an external power switch. Both the shut-down function and the power on/off incorporate click and pop suppression which prevents large transients from occurring and causing loud noises on the headphone outputs.

The amplifier gain is adjustable by the use of varying feedback resistor values.

The minimal set of external components is the four feedback resistors, AC coupling capacitors for the signal inputs (assuming it isn't already ground-referenced) and three relatively small low-ESR capacitors for supply bypassing and for the switched capacitor charge pump.

** Not specified in data sheet; determined by testing.*

Q1: DMP2215L

Manufacturer	Diodes, Incorporated
Description	P-Channel Enhancement Mode Mosfet
Package	SOT-23 (Small Outline Transistor, 2.9 x 1.3mm), 3 pins
Maximum Drain Voltage	-20V
Maximum Gate Voltage	±12V
Gate Threshold Voltage	Typically -0.89V, maximum -1.2V
Drain-Source On-Resistance	Typically 165mΩ, maximum 215mΩ (Gate = -2.5V)
Maximum Drain Current	2.7A @ 25°, 2A @ 70°
Drain Leakage Current	Maximum 800nA (Gate = 0V)

to about 15mA. If it doesn't light or if at any time the current exceeds 20mA, cut the power and check the board for faults such as reversed or incorrect components, wrong component values, solder bridges or short circuits.

Assuming you get a reading of about 15mA when the power is on and the on/off switch operates normally, turn the volume all the way down and plug in a signal source (eg, an MP3 player) and some headphones. Play some source material, put on the headphones and slowly turn the volume up. If you hear undistorted sound then all is well.

It's then just a matter of soldering the remaining battery wire, screwing the case together, attaching the front-panel label and pushing the knob on. The front-panel label is shown in Fig.12 and can either be copied or downloaded from the SILICON CHIP website and printed out. Laminate it and use spray adhesive to hold it in place.

To get the knob position correct, set the potentiometer to its mid-point and then push the knob on so that the pointer is straight up (ie, at right-angles to the end of the case).

Using it

You will need a short cable with 3.5mm stereo jack plugs at either end to connect your music player to the headphone amplifier's input. As mentioned earlier, it's always a good idea to turn the volume knob down before putting the headphones on. You can then turn the player volume up to maximum, to maximise its signal-to-noise ratio.

Note that the MAX4410 driver IC has click and pop suppression so there should be no loud noises if the amplifier is turned on and off while you are wearing the headphones. If, after some use, the power LED is dim and/or the sound is distorted, or the unit will not switch on, it's time to recharge or replace the battery. SC

By LEO SIMPSON

Fixing transformer BUZZ in the Class-A Amplifier

Since the 20W Stereo Class-A amplifier was published in 2007, it has been widely acclaimed for its sound quality. But there has been a consistent niggle experienced by quite a few constructors – low level buzz from the power transformer. We recently took a look at this problem and have come up with a cure.

WHEN WE PUBLISHED this amplifier in 2007 we were well aware of the low level buzz from the power transformer and we regarded it as inevitable. After all, in a Class-A amplifier, the load current is constant and always high, regardless of how much audio power is actually being delivered. That and the amount of heat produced are the two major drawbacks of class-A amplifiers.

But that constant load on the power transformer means that it is always working hard. In this case, it is delivering over 2A from the balanced ±22V (nominal) DC supply rails. That means the peak rectifier currents can be expected to be at least 10A and it is these heavy pulse currents at 100Hz which cause the audible buzz from the transformer windings. But we judged at the time that the buzz should not be a problem with the lid on the case, even when playing quiet passages of music in a quiet room.

And while we judged our prototype to be quite satisfactory, it is apparent that normal production variations mean that some transformers are noisier than some constructors would like. Just recently we have had a number of readers complaining and we were cogitating about the problem: maybe pot the transformer, use pliant mounting or some-such . . .

Then there was a moment of serendipity as one of our staff who had recently been reading one of the articles on Vintage Radio had a sudden thought: what if we tried a choke-capacitor filter for the power supply?

Choke input filters were widely used for the HT (high tension) rails in valve sets because high-voltage capacitors were expensive. And before permanent magnet loudspeakers became common place, the coil for the electromagnet in the loudspeaker did double duty as the choke for the power supply filter. But all of this clever circuitry fell into disuse as high-voltage capacitors became cheaper and more readily available and permanent magnet speakers became the standard. Such is the progress of technology.

So the design of choke input power supply filters has become something of a lost art. In typical valve radios, the iron-cored choke would have had an inductance of around five Henries and be rated for a current of no more than about 50 milliamps. The class-A amplifier has lower supply rails but much higher currents and in any case, we would not want such large values of inductance.

Why not? The answer is that a choke input power supply works quite differently from today's capacitor input power supply filters. In the latter supplies, the rectifier diodes conduct for only a short time during the peaks of the AC waveform, producing the high current pulses at 100Hz, as mentioned above.

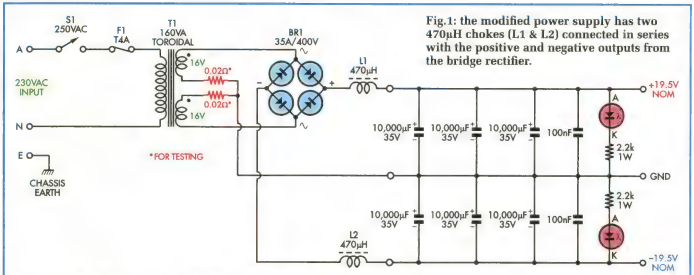


Fig.1: the modified power supply has two 470µH chokes (L1 & L2) connected in series with the positive and negative outputs from the bridge rectifier.

SC 20W CLASS-A AMPLIFIER POWER SUPPLY

By contrast, in a typical choke input power supply, the rectifier diodes, whether they be thermionic (ie, valve) or semiconductor, typically conduct over most of the 50Hz AC waveform so the high 100Hz pulse currents don't occur. The result is that the 100Hz ripple on the DC supply is more sinusoidal rather than sawtooth, as it is for capacitor input power supply filters.

Hence, we could expect the addition of chokes in series with rectifier outputs to the power supply board in the class-A amplifier might be able to reduce the transformer buzz. But not so fast. There is much more to choke input power supplies than meets the eye. In capacitor input power supplies, the DC rails are usually only slightly less than the peak value of the AC input waveform. For example, when 16VAC is rectified, you can expect a DC rail of about 22V. But in a typical choke input filter as used in vintage radios, the DC voltage will be a great deal less; about 90% of the RMS value of the AC voltage. That would be unusable in the Class-A amplifier because the reduction in the DC supply rails would greatly reduce the available audio power output.

So before we even started we knew that we would have use small-value chokes – just enough to give a useful reduction in the peak rectifier currents without an undue reduction in the DC supply rails.

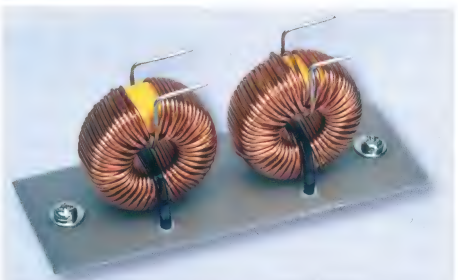
We won't detail the attempts that didn't work; instead, we will cut to the chase and give the solution which involves a pair of cheap and readily-available iron-dust toroidal chokes with an inductance of 470µH and a current rating of 5A. These chokes are much, much smaller than the chokes typically used in vintage radios.

Circuit details

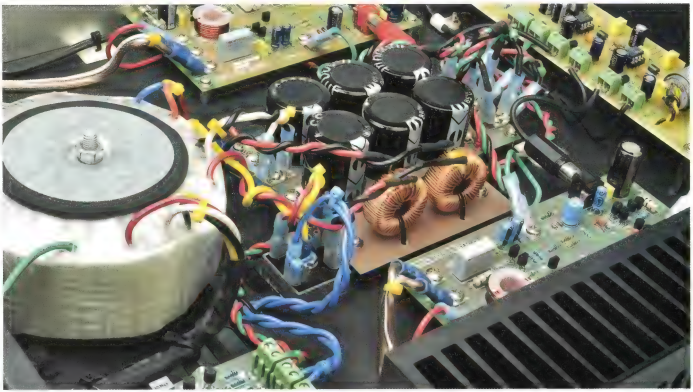
Fig.1 shows how the chokes, L1 and L2, are connected in series with the positive and negative bridge rectifier outputs to the capacitor bank of the power supply.

Electrically, the effect of these chokes is quite modest but it is enough to give a major reduction in buzz from the power transformer. To demonstrate the effect, we have produced a number of scope grabs showing conditions in the power supply with and without the chokes. Fig.2 shows the conditions from the standard power supply, without the chokes in circuit. The green and yellow traces show the 100Hz sawtooth ripple voltages superimposed on the positive (green) and negative (yellow) supply rails.

The magenta and cyan traces depict the rectifier currents flowing in the secondary windings of the power transformer. These short pulse currents charge the 30,000µF capacitor bank in the power supply. Notice that the individual winding currents are



The two 470µF chokes are secured to a piece of blank PCB material using Nylon cable ties. This assembly is then mounted in the chassis on 12mm standoffs and secured using M3 x 6mm machine screws and washers.



This close-up view shows how the chokes are mounted and wired into circuit. The outputs from the bridge rectifier go to the leads on one side of the chokes, while the leads on the opposite side go to the corresponding positive and negative inputs on the Power Supply Board. Be sure to use heavy-duty hook-up wire for the choke connections.

at 50Hz but since they are 180° out of phase, they result in 100Hz ripple on the supply rails.

We measured those pulse currents with a 0.02Ω (20 milli-ohms) shunt in each secondary winding, as shown on Fig.1 which is modified from the original power supply circuit published in June 2007 **(note: these resistors are shown in red and are not to be fitted for the purpose of this modification).** Given that the scope sensitivity for the current measurement is 100mV/div and the resistance is 0.02Ω, the pulse currents have an amplitude of 11A peak. Furthermore, the period of rectifier conduction in each half-cycle is about 3ms. No wonder the transformer buzzes!

Fig.3 shows what happened when the chokes were wired in place. Not only are the rectifier pulse currents slightly reduced in amplitude, down to about 10A peak, the period of conduction is now extended to about 5ms in each half-cycle. By the way, for this measurement, we inverted channel 4 of the scope (cyan) so that the pulse voltages are neatly superimposed.

OK, so the pulse currents are only a little less savage but that is not the whole story. You can also see that the 100Hz sawtooth ripple voltage waveforms are now smoother but there is also a drawback to the choke modification: the supply voltage has been reduced, from around ±19.5V to around ±18.15V. That is a significant reduction and will lead to a reduction in the maximum power output of the amplifier of a few watts. Fortunately, the audible effect of that order of reduction will be unnoticeable.

Installing the chokes

The recommended chokes are 470µH toroidal units rated at 5A and wound on sintered iron cores. They have a DC resistance of just 0.05Ω (50 milliohms). This low resistance is important because even with this low figure they will get hot. They are available from Altronics (Cat. L-6630) and Jaycar Electronics (Cat. LF-1278). Two chokes are required.

We installed the chokes on a piece of blank PCB material. This should be cut and drilled as shown in Fig.4, after which you can secure the chokes in place using Nylon cable ties. Bend the leads of the chokes at right angles, as shown in one of the photos

The completed choke assembly is mounted in the chassis between the Power Supply Board and the left-channel power amplifier board. You will need to carefully mark out the chassis mounting hole positions, then drill the holes to 3mm.

It's best to drill the holes from the underside of the chassis but you have to be careful to capture the metal swarf. Several layers of sticky tape on the inside of the amplifier and some strategically placed plastic wrapping can keep the swarf from contaminating other parts of the amplifier.

In addition, you should cover the ventilation slots for the power transformer on the underside of the amplifier before you start drilling. Be sure to position the holes accurately and use an oversize drill to remove any metal swarf from around the holes.

The choke assembly can then be mounted in position on 12mm tapped stand-offs and secured using M3 x 6mm machine screws and washers.

Connecting them up

The chokes must be connected into circuit using heavy-duty hook-up wire. The first step is to unplug the positive and negative leads from the bridge rectifier at the power supply board. The spade connectors are then clipped off each lead and the wire ends stripped and soldered to the leads on one side of the chokes. These connec-

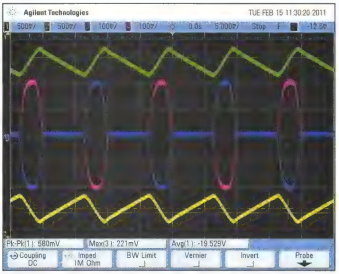


Fig.2 – standard power supply: the green & yellow traces in this scope grab show the 100Hz sawtooth ripple voltages superimposed on the positive & negative supply rails, while the magenta & blue traces show the rectifier currents flowing in the secondary windings of the power transformer.

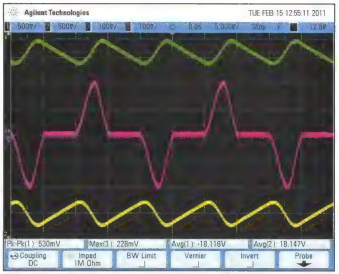


Fig.3 – modified power supply: here's what happens when the 470µH chokes are wired in place. The 100Hz ripple waveforms are now more sinusoidal with rounded peaks, while the rectifier pulse currents are slightly reduced in amplitude. In addition, the period of conduction has been extended from about 3ms to about 5ms in each half cycle.

tions should be insulated using short lengths of heatshrink sleeving.

After that, it's just a matter of running leads from the other side of the chokes to the positive and negative terminals on the Power Supply Board. These leads can be terminated with fully-insulated 6.3mm spade lugs to plug into the quick connect terminals.

Mains reduced to 230VAC

Keen-eyed readers who compare these voltage figures with those originally quoted in the 2007 articles will have notice a big discrepancy: the supply rails were originally ±22V. Why the big reduction?

There are two reasons for this. The first is that Australia's mains voltage is now officially 230VAC and we frequently see mains voltages below that in the SILICON CHIP offices. Partly that is because the mains voltage is now generally lower but it also happens because of heavy machinery being used elsewhere in our building.

Indeed, if were presenting the Class-A amplifier in 2011 we would now specify a transformer with 18V secondaries rather than 16V, to cover this reduction in mains voltage. Unfortunately, the picture is a little more complicated though because there are areas of Australia when the mains voltage still exceeds 250VAC.

This reduction in mains voltage was highlighted by another problem which became apparent after we had

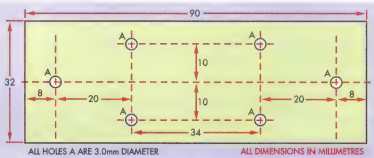


Fig.4: this diagram shows the dimensions and hole positions for the choke assembly PCB.

installed the chokes: the relay on the Speaker Protection & Muting board was reluctant to operate. While its internal LED was lighting up, the relay contacts were not closing.

The quick and easy cure for this is to replace diode D1 on the PCB with a wire link. If that proves ineffective, the relay will need to be changed to a 12V type (Altronics Cat. S-4311) and a 100Ω 1W resistor installed in place of the link originally shown for R2 on the PCB. These changes to the Speaker Protection Board are only necessary if the relay operation proves unreliable.

Performance testing

To verify that the addition of the supply chokes had not any deleterious effect on the performance of the 20W Class-A Stereo Amplifier, we ran all the significant measurements with the mains input voltage adjusted to 240VAC. There was no real difference apart from the absence of transformer buzz, although there is still a very subdued hum from the transformer.

The only difference in performance is a very slight increase in distortion from the left-channel amplifier, due to the proximity of the chokes. This could be avoided by mounting the choke assembly on the rear panel, between the power transformer and the Loudspeaker Protection Board.

Conclusion

If you are bothered by the buzz from your transformer, then you should consider installing the chokes as we have described. They will make a considerable difference.

However, if your mains voltage is low (ie, below 230V), you might think twice. If you do go ahead, you may need to also replace diode D1 on the Speaker Protection Board with a wire link, as described above. SC

Cheap'n'Simple 100V Speaker/Line Checker

By Ross Tester

This Speaker/Line Checker will be a boon to anyone setting up 100V PA systems, especially for temporary installations at sporting events, when you need to do everything quickly before the event and be sure that it is all working. With this tester, you can immediately check each PA speaker and line as it is run.

Necessity, as they say, is the mother of invention. My necessity was something to check both PA speakers and the lines feeding them as they were temporarily placed in position for surf lifesaving carnivals.

For many years, I've erected temporary PA systems – up in the early morning, down that afternoon. Usually, that's been a matter of placing perhaps eight horn speakers over a distance of maybe 600-700m, all fed from a central PA amplifier located where the carnival announcer sits.

With eight 30W speakers, a 250W amplifier handles the whole thing quite nicely. But feeding those eight speakers over such a distance demands they not be your usual low impedance (ie, 4, 8 or 16Ω) speakers; to minimise losses they must be so-called "100V" types.

What this means is that the output from the amplifier is (internally) stepped up by a transformer so that the lines to the speakers are fed by a 100V signal. At the speaker itself, the reverse happens – the 100V is stepped back down again by a similar transformer so that the low impedance speaker driver is presented with just the right level.

Why go to all that trouble?

The answer is simple: to minimise

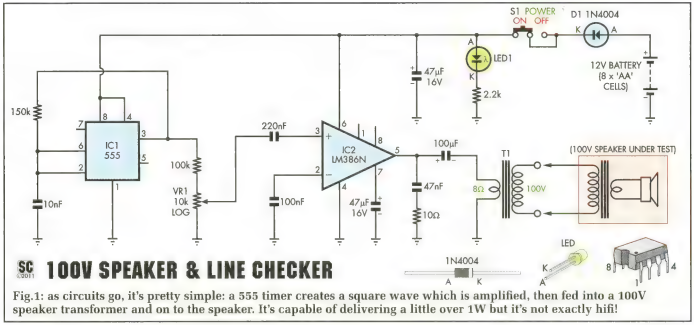


Fig.1: as circuits go, it's pretty simple: a 555 timer creates a square wave which is amplified, then fed into a 100V speaker transformer and on to the speaker. It's capable of delivering a little over 1W but it's not exactly hifi!

losses in the speaker cables.

While copper cable is a very good conductor, it does have some resistance. Typically, I use lightweight (14 x 0.14) Fig.8 cable, which according to the reference books has a resistance of about 16Ω/100m (ie, 8Ω per side).

In a home hifi situation with only a few metres of cable between amplifier and speaker that resistance doesn't matter too much but when your speakers are up to several hundred metres away from the amplifier, resistance of the cable has a major impact.

If, for example, I was to drive an 8Ω speaker 300m away from the amplifier, the speaker line itself is going to act like quite a large resistor in series – about 48Ω (3 x 16Ω) – and I am going to lose 48÷56 (ie, line resistance divided by line + speaker resistance) or 85% of the signal before it gets to the speaker.

In fact, it's even worse than that because inevitable corrosion in the connectors etc means I'd be lucky to have even 5-10% of my original signal left at the far end. And the further away your speakers are, the worse it gets.

With a 100V PA system, the losses are much, much lower. The impedance of a 30W 8 ohm "tap" on a 100V audio transformer is calculated as ($100V^2 \div 30$) or 333 ohms. So now we have a 48Ω speaker line in series with a 330Ω load. Therefore the loss is reduced to (48÷(48+330)) or about 12% – much more manageable.

No impedance problem, either!

There is another huge advantage: with multiple speakers, you don't have to worry about impedance matching. With a 100V line system, all speakers are connected in parallel/in phase and all you need to do is add up the wattage which each speaker is running at (and that simply depends on the tap you use on the speaker's transformer) and make sure the total doesn't exceed the rated output of the amplifier.

For example, I mentioned before I normally use eight 30W horn speakers (or more correctly, eight speakers connected to their 30W taps), 8 x 30 = 240, nicely inside the rating of my 250W amplifier.

Incidentally, if you need to add another speaker or so to fill in a "sound hole" in a 100V system and you're running close to the amplifier's maximum power rating, lower the tap on one or more speakers so that when you add the extra(s), you stay within the overall power limit. Simple, eh?

Back to the checker

As I've installed the PA systems, many's the time I've wished for some method of ensuring that the lines and speakers were working properly as I go. "Easy," you're thinking. "Just get

Inside the box: everything except the transformer, output terminals and batteries mounts on a single PCB. The batteries in their holders can just be seen underneath the board.

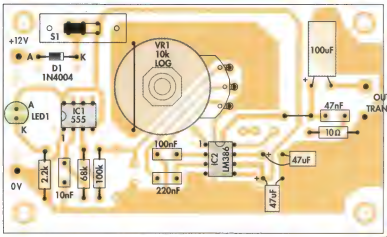


Fig.2: the component overlay and matching photo below. Note that the capacitors are all laid over so there's enough room underneath the case lid. The empty holes in the PC board are for adjustment to the 555 output waveform (left holes) and the LM386 gain (centre/right holes), as explained in the text.

someone on the microphone to talk as you go."

Not so easy, especially when the system is installed at a beach at 5AM – with people living all around! For a start, that requires two people to do the installation and I normally do the job by myself.

Second, nothing gets residents offside quicker than someone saying "testing 1-2" when they're enjoying their beauty sleep.

So what I wanted was something that would generate a low level tone; just loud enough to ensure that the speaker lines hadn't been cut (it happens!) or the speaker itself hadn't developed a mysterious case of silence (ditto!). Then I could test each PA horn and the reels of cable as I went.

The circuit

The circuit is dead simple; crude even – see Fig.1. Our old friend, the 555 timer, is connected in astable mode so it produces a square wave at about 400Hz or so. It feeds an LM386 power amplifier IC via the volume control pot (VR1). The LM386 gain is set at 20 due to the fact that pins 8 and 1 are left open circuit.

Provision is made on the PC board for components to (a) shape the output wave somewhat – effectively in parallel with VR1, and (b) to adjust the gain of the LM386 if required (components between pins 8 and 1).

A 10µF capacitor and series resistor will set the gain, from 20 up to 200, depending on the resistor value (open circuit = 20, short circuit = 200).

While we made this provision, we were happy with both the tone and the gain, so these pads are left empty.

You can also adjust the frequency from the 555 by varying the 150kΩ resistor or the 10nF capacitor. For example, 68kΩ and 10nF gives about 1kHz.

Normally, the output of the LM386 at pin 5 would drive an 8Ω speaker via the electrolytic capacitor (the Zobel network of a 470nF capacitor and 10Ω resistor to ground at pin 5 helps prevent supersonic oscillation).

But in our case, instead of driving a speaker, we drive the primary (ie, 8Ω winding) of a 100V speaker transformer.

The secondary is taken to a pair of binding posts which can connect to speaker cables. But because my speakers and cables are all wired with XLR plugs and sockets for quick connection, I've included a male XLR socket as well. That makes checking fitted leads really quick and easy – just plug 'em in!

To make it truly portable, power is supplied by eight AA cells, giving a 12V rail. This connects via a silicon diode (D1) to protect against polarity reversal and thence to an on-board power switch.

A LED pokes through the front panel to show that power is applied, with a large volume control knob alongside.

Just in case you're wondering why we didn't simply connect the LM386 to oscillate and produce a square wave (which it can do easily) we wanted to make the level variable – and it's just as easy to do that with a $1 555.

Construction

With the exception of the 100V

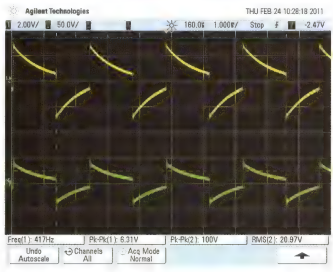
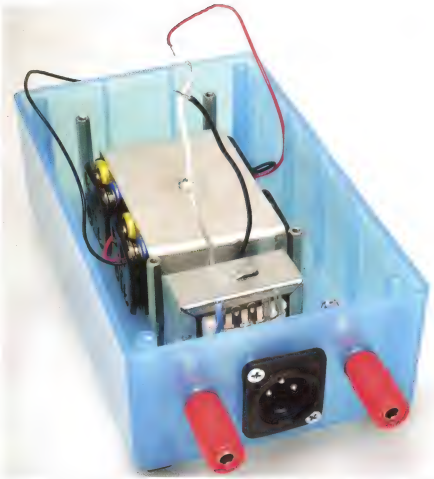


Fig. 3: the top trace shows the output of the amplifier while the lower (green) trace shows the (unloaded) output from the 100V transformer. OK, it's not exactly a textbook square wave – but I find the distortion actually makes the sound a little more distinctive.



The two 4 x AA battery holders are clamped in place by a scrap of aluminium. In this shot you can also see the mounting pillars on which the PCB sits, along with the output terminals and optional XLR socket.

output transformer, binding posts/XLR socket and battery packs, everything is mounted on one PCB, coded 04104111 and measuring 100 x 60mm.

First step, then, after checking the PCB for defects, is to mount the components.

Start with the seven PC pins (two for power, two for output and three for potentiometer) then the resistors, low profile capacitors, diode and then the electrolytic capacitors.

Note that the electros are all mounted "laid over" so their height does not interfere with the front panel. When mounting the LED, it should sit about 5mm above the PC board surface so it can just poke through the panel.

The slide switch mounts hard down on the PC board, which makes it just the right height to emerge through the panel without being too proud of it. We deliberately selected this type of switch so it would be harder to knock on when bouncing around in the gear bag! Note that it will almost certainly be a DPDT type as SPST are not easy to find!

Before mounting the 10kΩ log pot, it would be wise to cut off the excess shaft, to the length required for the knob you choose. The pot itself mounts flat onto the PCB so its three terminals can solder to the three PC pins.

You will note a couple of holes in the board alongside the pot – these are for a length of tinned copper wire which goes over the top of the pot to ensure it stays in place.

We soldered the wire to the pot body, after scratching away some of the passivation on the body (it won't solder otherwise).

Finally, solder in the two ICs – making sure you get them in the right spot and oriented the right way.

Checking

Before mounting the PCB in its box, it should be checked. It's so simple it should work first off. Connect 12V DC to the power terminals (watch the polarity) and turn on the switch.

Ensure that the LED lights. If it doesn't, you either have a dead power supply or it is connected back to front (or perhaps you've put the LED in back to front).

Wind the pot down to minimum and connect virtually any normal (ie, low impedance) speaker to the output pins on the PC board. As you wind the pot up you should be rewarded with a raspy tone which increases in volume.

If you don't, switch off and check your soldering – especially for dags between the IC pins and for dry joints – and also your component placement and, if applicable, polarity.

Final construction

Using the photos as a guide, drill the nine holes required in the Jiffy box – four for the PCB mounts, two

Parts List – 100V Speaker/Line Checker

1 UB-1 Jiffy Box, 158 x 95 x 55mm
1 PC board, coded 04104111, 100 x 60mm
2 4 x AA cell holders
1 8Ω to 100V 5W speaker transformer (T1) (eg, Altronics M1112 or equivalent)
1 SPST slide switch (eg, Jaycar SS-0812 [DPDT] or equivalent)
2 binding post terminals
1 chassis-mounting male XLR socket [optional]
1 knob to suit potentiomenter
1 pack 4 rubber feet, self adhesive
4 25mm threaded pillars
4 12mm threaded pillars
8 10mm x M3 screws
4 20mm x M3 screws
4 M3 nuts
7 PC pins
Aluminium sheet (for battery clamp)

Semiconductors
1 555 timer IC (IC1)
1 LM386 Audio amplifier IC (IC2)
1 1N4004 silicon power diode (D1)
1 5mm LED (LED1)

Capacitors
1 100µF 16V electrolytic
2 47µF 16V electrolytic
1 220nF MKT or monolithic
1 100nF MKT or monolithic
1 47nF MKT or monolithic
1 10nF MKT

Resistors
1 150kΩ 1 100kΩ 1 2.2kΩ
1 10Ω
1 10kΩ log pot, 24mm (VR1)

for the transformer, one for the battery holders (all in the base) and two for the terminals on the end (plus, if you wish to use an XLR socket, a larger hole [usually 18mm]).

The PC board itself sits 37mm above the bottom of the case on suitable pillars. We used a combination of a 25mm and 12mm threaded pillars to make up the distance with four 20mm screws holding them in place from underneath and a 10mm screw holding the PCB onto the pillars.

If you have difficulties finding the right length pillars, one cheap trick we have used in the past is to use plastic wall plugs as pillars – they're easy to obtain and easy to cut to the appropriate length with a sharp (hobby) knife. The dark blue ones (10mm) make a nice secure "platform" and you can use small self-tapping screws.

When in place, the PC board sits hard up against one end of the case and actually slightly overlaps the transformer, with a clearance of perhaps 2mm or so.

So if you wish the transformer could be mounted further under the PC board, as long as none of your soldered joints under the board can short to it. To do this, though, you will first need to disconnect and remove the 2-way terminal block on top (we'd done this anyway because we needed a terminal block for another project and this one is redundant!).

We mounted the XLR socket between the two terminals, with pins 1 and 3 connected to the terminals (ie, in parallel). There's not a great deal of room between the XLR socket and the transformer – in fact, we had to cut the ends off the XLR socket solder pins to give us enough room for the transformer and PC board.

Solder wires from the common and 5W transformer taps to the output terminals. Most transformers have flying leads on their primaries; solder these to the output terminals on the PC board (if no flying leads, look for the "primary" or "8 ohm" labels).

Because it is not easy to buy suitable chassis-mounting 4 x AA holders (although Altronics has one) we used two ordinary 4-cell "AA" battery holders which go alongside each other under the PC board.

Fitting the XLR socket required some minor surgery to the back of the pins to allow it to fit in – but there's still plenty of meat to solder to. Note that the 2-way terminal block has been removed from the top of the transformer – it's redundant because the output leads solder straight to the appropriate taps.

These were connected in series (one red to one black wire) with the other red wire going to the + terminal on the PC board and the black wire, obviously from the other battery holder, to the – terminal.

To hold them in place we used a scrap of aluminium as a clamp and a single screw and nut coming up through the bottom of the case onto the clamp to hold the battery holders firmly in place.

If you can find chassis-mounting 4 x AA holders, connect them the same way but secure them to the bottom of the case alongside each other using suitable screws and nuts.

To avoid scratching the boss's desk (he's got a thing about that), we placed four small self-adhesive rubber feet in the corners of the case.

You're almost finished! Drill the front panel for the pot shaft (10mm hole), LED (5mm hole) and the slot for the on/off switch (4mm wide x ~10mm long).

Place the lid on, making sure the LED, switch and pot shaft all come through where they are supposed to and put on your pot knob (we didn't worry about a pot nut). Finally, screw in the four lid screws and you're done!

How to use it

I'm sure everyone who puts together temporary PA systems has their own way of working – but this will give you an idea of how I do it – especially now I can check the installation as I go.

Usually, I erect all the horn speakers where I want them first, then go back and roll out the cables which connect them together. There is a reason for this: I know where each area of the carnival is to be set up so provide speaker coverage for those areas.

The speakers are "daisy chained" one to the next – not in series but as I mentioned earlier, all in parallel.

Each of my reels of cable has two XLR male sockets on the reel itself and an XLR female plug on the other end. A short female-to-female patch lead connects the reel to the speaker, while the second XLR socket on the reel is ready to accept the female plug on the next reel, going off to the next speaker.

All are wired the same way, using pins 1 and 3 of the XLR plugs, so I never have a problem with phasing.

With this gadget, I don't need an amplifier connected (which probably won't even have power available at that time of day) nor do I need a second person.

I simply go to the furthest speaker, plug it into the checker and make sure it's OK. Then I plug in the patch lead and if it tests OK, I plug it into the still-rolled-up cable and plug the checker into the opposite end – again, the tone tells me if it is good.

I then roll out that cable back to the previous speaker and repeat the procedure. So at each speaker I'm checking it, the patch lead and the cable reel.

You'd be amazed the number of times a reel of cable tests no-go – so I can substitute another roll right then and there.

It saves having to come back later to swap it all out (and also having to roll out the cable twice). SC

Resistor Colour Codes

No.	Value	4-Band Code (1%)	5-Band Code (1%)
1	150kΩ	brown green yellow brown	brown green black orange brown
1	100kΩ	brown black yellow brown	brown black black orange brown
1	2.2kΩ	red red red brown	red red black brown brown
1	10Ω	brown black black brown	brown black black gold brown

Capacitor Codes

Value	μF value	IEC Code	EIA Code
220nF	0.22μF	220n	224
100nF	0.1μF	100n	104
47nF	0.047μF	47n	473
10nF	0.010μF	10n	103

APRIL Projects

Kingray Masthead Amplifiers

Featuring the same quality Australian design and performance that has become synonymous with the Kingray brand, this new "KM Series" of masthead amplifiers brings you clear digital (and analogue) TV reception for a more affordable price than previous models.

KMD24FS 24dB Masthead Amplifier Optimised for Digital TV

- Input filtering rejects VHF Band 1, to optimise digital TV reception.
- Combined or separate antenna inputs
- Frequency range: VHF 174-230MHz, UHF 520-820MHz
- Max gain: VHF 15dB, UHF 24dB
- Gain control: VHF 10dB, UHF 10dB
- Noise figure: VHF <3dB, UHF <2.5dB
- Max output: 108dB @ -60dB IMR (DIN45004B)
- Supply voltage: 17.5VAC
- Replacement power supply LF-3258

LF-3254

$69.95

KMD32FS 32dB Masthead Amplifier

- Wide input range to suit all analogue and digital TV signals
- Higher amplification for installations with several TV outlets
- Combined or separate antenna inputs
- Frequency range: VHF 44-230MHz, UHF 520-820MHz
- Max gain: VHF 26dB, UHF 32dB
- Gain control: VHF 10dB, UHF 10dB
- Noise figure: VHF <3dB, UHF <2.5dB
- Max output: 108dB @ -60dB IMR (DIN45004B)
- Supply voltage: 17.5VAC
- Replacement power supply LF-3258

LF-3255

$74.95

Helicopter Spy Camera

Check This Out!

A tiny camera that weighs less than 30 grams and is designed to mount on a model RC helicopter - yes, a helicopter! or RC planes, cars or hovercrafts etc. It features a ball swivel lens as seen on real military helicopters and delivers recorded video straight to your computer via a mini USB port, which also recharges the camera battery. 4GB internal memory gives about 4 hours of recording time with continuous video audio and programmable still photos.

- Shockproof construction
- 90 degree viewing angle
- 60 degree lens rotation
- Mounting bracket included
- Size: 80(L) x 19(Dia)mm

QC-3820

$129.00

Note: Helicopter not included

Cup Holder Power Extender with Dual USB Sockets

Plugs into your single cigarette power socket and gives you two cigarette power sockets and two USB power sockets, all whilst sitting in your vehicle's cup holder. Features LED voltage indicators to show battery condition.

- 1.6m lead
- Input voltage: 12-24VDC
- Maximum current: 10A (fused)
- USB outputs: 5VDC 1.0A + 0.5A (1.5A total)
- Dimensions: 76(Dia) x 65(L)mm

PS-2120

$19.95

In-Car Bluetooth® FM Modulator

Play music or even video stored on an SD card, USB stick or any other media device through the FM radio in your car. You can control the playback by remote control or via the steering-wheel mounted remote unit. Pair it with your Bluetooth® mobile phone for hands-free operation. A remote earpiece is included which enables you to make and receive calls completely wirelessly.

- 2.4" colour LCD
- Supports MP3, WMA formats
- Caller ID
- Automatic last memory
- USB cable and 3.5mm audio cable included
- Remote control included
- Size: 70(W) x 65(H) x 22(D)mm

AR-3111

$99.00

Also available: **MP3/USB FM Modulator for iPhone® and iPod®** AR-3113 $49.95

Note: iPhone® not included

12V 120W 3-Step MPPT Solar Charge Controller Kit

Charge controllers are essential for solar setups however commercial units can run into several hundred dollars. Designed for use with 40W to 120W 12V solar panels and lead acid batteries, this solar charger provides 3-stage charging with the option of equalisation and with MPPT (Maximum Power Point Tracking). The kit is configured for 12V operation, a 24V upgrade will be available in the future. Kit includes PCB, all components and case.

- Suitable for 40W to 120W 12V solar panels
- 3-step charging
- MPPT (Maximum Power Point Tracking) charging
- Charge indicator LEDs
- Temperature compensation for charge voltage
- Optional equalisation cycle
- Optional 24V 80W to 240W operation upgrade

KC-5500

$129.00

Kit of the Month

Waterproof Sport Action Camera

Mount this handy action camera with 360 degree rotating base onto your bicycle or motorcycle handle bars and record every bump and jump straight onto a MicroSD card with up to 32GB of storage. Designed for wet weather conditions and includes an optional helmet strap. USB & TV out cables also included for TV & PC CAM mode, driver installation required.

Specifications:

- Resolution: 1.3MP
- Video resolution: 720 x 480 @ 30 fps
- Built-in rechargeable Lithium battery
- Ingress protection: IP67
- Supports: Windows 2000, ME, XP & Mac OS X
- Dimensions: 87(L) x 20(Dia)mm

QC-8012

$99.00

IPX8 Rated ABS Cases

Specified to IPX8 for continuous immersion to protect your valuable gear. All feature O-ring seals, stainless hinges, padlock rings, lanyards and a transparent lid so you'll know what you put where. Very tough cases suitable for boating, 4WD, fishing, camping or kayaking. A range of sizes to take anything from a mobile phone to a multimeter and tools.

- IPX8 rated
- Lockable
- Lanyard included

FROM $14.95

MPS1 ABS Case

Dimensions:
Internal: 110(W) x 68(D) x 31(H)mm
External: 132(W) x 100(D) x 40(H)mm
HB-6420 $14.95

MPS201 ABS Case

Dimensions:
Internal: 158(W) x 90(D) x 32(H)mm
External: 182(W) x 120(D) x 42(H)mm
HB-6424 $19.95

MPS202 ABS Case

Dimensions:
Internal: 158(W) x 90(D) x 72(H)mm
External: 182(W) x 120(D) x 75(H)mm
HB-6428 $22.95

MPS302 ABS Case

Dimensions:
Internal: 200(W) x 100(D) x 83(H)mm
External: 224(W) x 130(D) x 88(H)mm
HB-6430 $29.95

Travel Companion

Buy both for $179.00 SAVE $19.95

7" TFT LCD Widescreen Colour Monitor

Suitable for in-car entertainment, use it to watch DVDs, PS2®, XBOX®, etc. Unit comes with an adjustable swivel bracket with double sided tape for adhesion on clean flat surfaces. A very slim and small infrared remote control is included.

- Power input: 12VDC
- High resolution
- Ideal for rear seat passengers

QM-3752

$159.00

Wireless Stereo Headphones

Having the kids watching DVDs in the back of the car is all very nice, but you don't want to be blasted for hour after hour. Add a pair of wireless headphones and enjoy automotive bliss. Soft cushioned earpads for comfort, switchable between channel A and B.

- Driver diameter: 27mm
- Nominal impedance: 32 ohms
- Frequency response: 120Hz - 20kHz

AA-2047

$39.95

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Surveillance Equipment

40m Vari-Focal Pro IR Camera

A quality camera ideal for long range outdoor surveillance. Robust aluminium case provides excellent cooling performance while maintaining the IP68 rating. The Sony® Super HAD sensor and the camera's 42 infrared LEDs enable the system to capture images up to 40 metres away in total darkness. The IR LEDs can be switched from low, medium or high illumination for different distances. The camera is supplied with sun hood, mounting bracket and hardware.

$399.00

- Flickerless
- 2 Stage Auto gain control
- Back light compensation
- Sensor: 1/3"
- Sensor brand: Sony® HR SuperHAD II
- Sensor resolution (H x V pixels): 752 x 582
- Resolution (Horizontal TV lines): 550TVL
- Minimum illumination: 0.02 lux (IR off), 0 lux (IR on)
- Lens: 9.0-22.0mm/F2.0 Autoiris with ICR
- IR range: 40m
- Power requirements: 12VDC
- Current draw: 840mA max
- Dimensions: 180(L) x 106(W) x 110(H)mm excluding bracket

QC-8613

Network 4 Channel H.264 DVR with VGA 500GB HDD

A combined multiplexer and digital video recorder that delivers quality image reproduction at a touch of a button. It will accept up to 4 video inputs and its incorporated Ethernet capability so it can be accessed (with password protection) via the internet by a standard web browser. Also access footage on your iPhone®* or other smart phone after downloading the compatible app. The unit features H.264 compression, VGA monitor connection, motion trigger recording, video loss detection, remote network record and USB back-up support. The unit comes fitted with a 500GB HDD and includes software & manual disc, power supply and quick start guide. See website for full specifications.

QV-8105

$399.00

DIY Security

10 Zone Wired Alarm Kits

Fully configurable and programmable, these wired alarm kits give you complete control over a professional system for home or business. Each kit comes with a central controller and the sensors you need to get a basic system up and running, then you can add sensors and functionality as required. Up to four remote keypads can be installed with a 100m range and each can be named for easy identification.

- 10 programmable zones
- 4 access levels • Walk test mode
- Events memory in keypads
- Programmable timers for entry, exit and alarm duration

Both kits come with the following:

- 1 x Control panel
- 1 x Bellbox
- 1 x 12V 1.2Ah backup battery

FROM $299.00

Alarm with LED Controller

1 x Reed switch
2 x PIR sensors
1 x 50m cable
LA-5560
$299.00

Alarm with LCD Controller

2 x Reed switch
4 x PIR sensors
2 x 50m cable
LA-5562 $399.00

LA-5562 shown

Spare controllers and sensors also available:

LED Remote Controller LA-5561 $49.95
LCD Remote Controller LA-5563 $69.95
PIR Sensor LA-5564 $29.95

Solar CCTV Warning Sign

A visible deterrent that will really get attention. With a built-in solar cell, this CCTV warning sign flashes when there is light available. Double sided tape is included for convenient mounting to any surface. Ideal for shops, homes, garages or anywhere you need to advise would-be robbers that you have an expensive CCTV surveillance system (even if you don't).

- Dimensions: 80(L) x 80(W)mm

LA-5103

$14.95

2.5" LCD Electronic Door Peep Hole Viewer

new

Eliminates the small distorted fish eye view of a traditional door peep hole. No more squinting or hunching over to peer through a small hole. With its big 2.5" LCD screen and built-in distortion compensation feature, you are able to see the person clearly on the other side of the door by a simple press of a button. The camera is no bigger than an original fish eye viewer and looks the same from the outside. It is very simple to install without compromising door security, it comes complete with an installation tool and AA batteries.

$199.00

- Screen measures: 146(W) x 90(H) x 30(D)mm

QC-3267

Mini DVR Kit with Button-Hole Camera

The ultimate personal surveillance tool. Capture meetings, conferences or lectures with this high definition video and audio mini DVR kit. Will store up to 32GB on an SD card, then allow video viewing on the 2" TFT LCD screen or download to a PC. The kit includes a pinhole camera with different buttonhole options so it's completely covert and discreet. Also includes a Li-ion rechargeable battery, charger, AV leads, USB cable, software and dummy buttons for disguising the camera.

$229.00

SAVE $20.00

- Recording resolution: Up 720 x 576
- Approx 10 hours of video
- 128MB flash memory
- Camera resolution 420TV lines
- Windows XP, Vista, 7 compatible

Dimensions:
DVR: 65(W) x 54(H) x 14(D)mm
Camera: 22(W) x 34(H) x 15(D)mm

QC-8006 WAS $249.00

Solar Powered Mini Window Alarms

A cost-effective and simple security measure. Peel the backing from the self-adhesive mount and position on the inside of a window or door. The solar cell keeps the built-in battery charged and if triggered, the very loud alarm sounds.

$24.95 each

- Warning sticker included
- 3 year warranty
- Size: 70(W) x 82(H) x 8(D)mm

Two types are available:

Mini Glass Breakage/Vibration Window Alarm LA-5003 $24.95
Mini Magnetic Entry Alarm LA-5005 $24.95

2-Zone Alarm Kit

new

Simple two zone, two wire alarm for small to medium size premises. Included is one passive infrared sensor for large areas and a reed switch for one entry point such as a door or window. It also has the visible deterrent of an external siren box and additional sensors can be added if required. Everything you need to protect a small house or apartment.

Kit includes:
1 x 2-Zone control unit
1 x PIR sensor
1 x Reed switch
1 x 25m cable
LA-5480

$99.00

Spare PIR Sensor LA-5481 $24.95

Budget Four Channel Digital Video Recorder with Four Cameras

This system allows you to monitor and record 4 locations at your home or office. This great value digital video recorder (DVR) package can store over 150 hours of video on the installed 250GB hard drive. Recording set-up is simple and various trigger modes can be set across the day including timer, motion detection, and manual recording.

The system comes complete with:

- 4-channel DVR with 250GB HDD, USB port, and 1 x composite video output
- 4 x weather resistant colour day/night cameras
- Plug-in interconnection cables
- Remote control
- Mains adaptor and user manual

QV-3063
WAS $599.00
Limited stock

$399.00

SAVE $200.00

IP68 3-Axis Cameras with Concealed Cable Bracket

High quality IP68 rated cameras with 3-axis movement through a wide range. The power and video cables exit through the base so they are completely concealed from prying cutters. Compact and will fit unobtrusively into your surveillance setup. They're also equipped with IR LEDs so they will work in darkness with a 20 metre range. Models include high resolution 550TVL, an economical 380TVL and a dummy camera.

FROM $49.95

3-Axis Outdoor IR Camera 380TVL QC-8611 $129.00
3-Axis Outdoor IR Cameras 550TVL QC-8612 $249.00
Dummy IP68 3-Axis Camera with Concealed Cable Bracket QC-8610 $49.95

All Savings are based on Original RRP
Limited stock on sale items.

Electromagnetic Door Locks

Compatible with any access control system, magnetic door locks meet the most rigorous building and fire safety codes. No moving parts, instantaneous release, holding force of 180kg or 280kg. Both operate from 12VDC and are finished in satin anodised aluminium. Suitable for in-opening or out-opening doors. Mounting hardware and drilling templates included.

180kg Electromagnetic Door Lock

- Operating voltage: 12VDC
- Current: 380mA
- Holding force: 180kg
- Dimensions: 170(L) x 41(W) x 21(H)mm

LA-5060 WAS $79.95

Accessories available:

Z L Bracket LA-5061 $39.95
L Bracket LA-5062 $24.95

$69.95
SAVE $10.00

280kg Electromagnetic Door Lock

- Operating voltage: 12VDC
- Current: 500mA
- Holding force: 280kg
- Dimensions: 250(L) x 49(W) x 25(H)mm

LA-5063 WAS $99.00

Accessories available:

Z L Bracket LA-5064 $39.95
L Bracket LA-5065 $24.95

$89.00
SAVE $10.00

8 Zone Wireless Alarm Kit

NEW

Wireless alarms are a great way to add security to your house, apartment or business without the daunting and invasive process of running cables everywhere. The system learns what sensors are connected and the part arm function allows you to protect certain zones while others are disarmed. The kit has everything you need to make your place secure.

Kit contents:

- Siren and bellbox
- Keypad, PIR sensor
- Reed switch, 9V plugpack

Features:

- 8-zones, 3 mode arming
- Battery backup
- Learning function
- Panic alarm

LA-5150

Spares sensors and accessories also available:

PIR Sensor LA-5151 $39.95
Reed Switch LA-5152 $34.95
Battery Pack LA-5154 $14.95
Remote Control Key Fob LA-5155 $24.95

$219.00

USB Mini Inspection Camera

NEW

Add a laptop as a monitor and you have a compact inspection camera for probing into all manner of places - checking for terminates and other rodents, insulation, finding lost tools etc. The camera is only 10mm in diameter and has two variable intensity LEDs for illuminating the area under examination.

- Mirror and magnet pick-up tool included
- Software included
- USB powered
- Size: 10(Dia) x 520(L)mm

QC-3383

$39.95

7" LCD Monitor Surveillance Kit with 2 x CMOS Cameras

NEW

Simple, cost-effective surveillance solution for small scale indoor applications such as shops and small offices. The kit consists of everything required - LCD colour monitor, cameras, cables, mains adaptor, remote and brackets. See website for full specs.

- Resolution: 480 x 234
- Dimensions: 186(W) x 86(H) x 30(D)mm

QC-3640

$199.00

CCTV Field Monitor 2.5" TFT

The smallest and lightest CCTV monitor on the market. Setting up and debugging CCTV and surveillance systems has never been easier. Rechargeable and ultra-portable. Complete with BNC cable, instruction manual and charger.

- Screen size: 2.5-inch
- Pixel: 480 x 234
- Power: 5VDC (with rechargeable built-in battery)
- Power consumption: 1.5W
- Weight: Approximately 90g
- Video input: PAL
- Dimensions: 85(L) x 64(W) x 20(D)mm

QM-3821 WAS $149.00

$99.00
SAVE $50.00

RF Bug Detector

Detects transmissions between 50MHz & 3,000MHz (3GHz). The unit can be operated in silent mode with the built-in vibrator & features an RF sensitivity control, a 'battery low' warning light and handy belt clip. Weighs just 90 grams with batteries.

- Measures: 55(W) x 92(H) x 25(D)mm

QC-3430 WAS $149.00

$129.00
SAVE $20.00

CCTV Camera Brackets

Professional Camera Mounting Bracket with Cable Management

This is a heavy duty, professional CCD camera bracket. It offers the strength of cast metal manufacture plus the durability of a powder coated finish. Rotates through 360 on the horizontal with almost 90 on the vertical. Cable management is provided through the centre of the bracket.

QC-3387 WAS $24.95

$19.95
SAVE $5.00

External CCD Camera Housing Mounting Bracket

Designed to mount our large indoor/outdoor professional camera housing and professional range of CCD cameras. Suitable for internal or external use, camera angle is fully adjustable.

- Mounting screws and wall plugs included
- Maximum Payload 8kg
- Heavy-duty aluminium
- Supplied in silver finish
- Bracket height is 290mm

QC-3337 WAS $19.95

$14.95
SAVE $5.00

Small CCD Camera Ceiling Grid Mounting Bracket

Designed to mount in the ceiling grid, the bracket supports fittings to mount any of our Professional CCD camera range.

- Beige finish
- Bracket Height: 70mm, includes a 30mm extension to extend bracket to 100mm

QC-3333 WAS $9.95

$7.95
SAVE $2.00

2 Station Wired Intercom

A simple low cost solution for communicating. Either station can signal the other even when the system is off. It can be used as a room/baby monitoring system.

- Operates on 9V battery or 240V plugpack
- Supplied with 20m of connecting cable and staples.

Domestic use only. Warranty does not apply if product is used industrially.

AM-4310

$24.95

Professional Dome Cameras

Colour Armour Dome (Vandal-Resistant) Camera

The dome of this camera is made of reinforced polycarbonate and is designed to withstand a 300kg impact without cracking. The base is made of solid diecast aluminium. It features 1/4" Sharp sensor and a 350 TV lines resolution.

- Dimensions: 92(Dia) x 70(H)mm

QC-3293

Also available:

3-Axis Vandal Resistant IR Dome Camera 550TV Lines
QC-8620 $349.00

$149.00

3-Axis Colour Dome Cameras

3-axis mechanism provides easy installation and enables you to put the camera's field of view exactly where required. Quality Sony sensors and optics, models include high resolution 550TVL and economical 380TVL.

3-Axis Dome Camera 380TV Lines

- Resolution: 380TVL
- Dimensions: 110(Dia) x 85(H)mm

QC-8616 $99.00

FROM $99.00

3-Axis Dome Camera 550TV Lines

- Resolution: 550TVL
- Dimensions: 110(Dia) x 85(H)mm

QC-8617 $199.00

3-Axis Vari-Focal Colour Dome Cameras

Varifocal dome cameras with 3D gimbal mount enabling the camera to be mounted in almost any direction on a roof or wall. These cameras also feature 20m infrared illumination & varifocal autoiris lenses with ICR.

3-Axis Dome Camera with IR 380TV Lines

- Resolution: 380TVL
- Dimensions: 110(Dia) x 85(H)mm

QC-8618 $189.00

FROM $189.00

3-Axis Dome Camera with IR 550TV Lines

- Resolution: 550TVL
- Dimensions: 110(Dia) x 85(H)mm

QC-8619 $269.00

HDMI Over Cat 5/6 Extender

Most HDMI over Cat 5/6 extenders available use two cables for data and signal transmission. This extender only utilises one Cat 5/6 cable reducing the cable costs further on transmission over great distances. Both unshielded twisted pair (UTP) and shielded twisted pair (STP) cables may be used, however shielded is recommended.

- Size (sender & receiver): 100(W) x 66(D) x 26(H)mm

AC-1681 WAS $149.00

$129.00

SAVE $20.00

AV Selectors

$24.95

4-Way AV Selector

Connect up to four AV devices such as DVD players, VCRs or gaming consoles with a single output to your TV and switch between them as required. Inputs can be either composite or S-video. Easy-to-use pushbutton front panel.

- Composite and S-video inputs
- Dimensions: 190(W) x 112(D) x 47(H)mm

AC-1652

4 Input AV Switcher with Remote

new

Switch between four composite or S-Video inputs, including stereo audio, and output to composite or S-Video. Control everything via remote. 9VDC mains adaptor included, remote requires 2 x AAA batteries.

- Dimensions: 200(W) x 45(H) x 108(D)mm

AC-1653

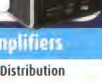
Due mid April

$39.95

Mini MicroSD Card Speaker

new

Now you can take the music wherever you go. It's a rechargeable active speaker in a solidly built aluminum casing. It can take a MicroSD card full of music files and play them in order or you can pause, play or skip to another track. It can be used as a laptop or computer speaker or plugged into a range of other devices such as iPods®, iPads® or any device that has an earphone jack. It also has an internal battery for charging via USB.



- Dimensions : 74(L) x 50(W) x 52(H)mm

XC-5176

Due mid April

$39.95

MP3 Player to Cassette Adaptor

Play your favourite MP3 tracks in any car cassette player or use it as an MP3 player. Just plug in your media card with your music files, load it into the cassette deck in your car stereo and control the music with the remote unit. You can also plug in your headphones and use it as a stand-alone MP3 player or connect to your PC using the included USB cable.

- Supports SD, mini SD and MMC cards
- Remote cable 450mm long
- USB cable and cigarette lighter adaptor included
- 8 hours playing time from one charge.

AR-1764 WAS $69.95

$39.95

SAVE $30.00

Composite Video / S-Video to Component Format Converter

Designed to convert standard Composite and S-Video signals from DVD players, set top boxes, gaming consoles etc. to either RGB or YCbCr component video for connection to SDTV or projectors. It is easy and simple to use, the unit automatically recognises the source input and has a power saving mode.

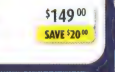
- Suitable for worldwide video system of NTSC3.58, NTSC4.43, PAL, PAL-M, PAL-N and SECAM
- Supports composite video and super video input
- 5VDC Power supply included
- Dimensions: 145(W) x 90(L) x 32(H)mm

AC-1629 WAS $149.00

$129.00

SAVE $20.00

Cat 5 AV 4-Way Distribution Wallplate Hub



An integrated solution for extending AV signals over Cat 5 cable. The entire hub is contained in a wallplate assembly and allows extension of up to 300m. Includes transmitter, receiver, IR emitters and power supply.

- Bandwidth video: DC - 12MHz
- Bandwidth audio: 50Hz - 15kHz
- Power supply: 12VDC 500mA

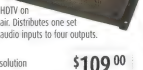
QC-3689 WAS $169.00

$149.00

SAVE $20.00

Audio Video Amplifiers

4-Way AV Component Distribution Amplifier



Offering the extra flexibility of component video, this AV distribution amp allows you to take advantage of HDTV on digital pay-TV and free-to-air. Distributes one set of component and stereo audio inputs to four outputs. Mains adaptor included.

- Supports up to 1080p resolution
- 12VDC 500mA power supply
- Dimensions: 190(W) x 90(H) x 23(D)mm

AC-1648

$109.00

4 Way AV Stereo Distribution Amplifier

Designed to split a stereo AV signal across 4 channels without loss of image or sound quality. You can wire any room where you would like to access audio and video from a central source. You can also use it to record to up to four sources at the same time. 12VDC operated. Mains plugpack and input cable included.

- Dimensions: 176(W) x 90(H) x 25(D)mm

AC-1646

$79.95

HDMI Switchers

2-Input HDMI Switcher

The tiny switcher routes high definition video (in multiple resolutions up to 1080p) and digital audio from any one of the two sources to display unit. Two inputs accommodate the simultaneous connection of upto two high definition video sources, such as satellite systems and HD DVD players. Switching is done automatically when signal is present on the ports or manually via the push button switch on the unit.

- Dimensions: 80(L) x 43(W) x 15(H)mm

AC-1691 WAS $44.95

$34.95

SAVE $10.00

4 Port HDMI Switcher with SPDIF/Coaxial Audio Splitter

HDMI integrates audio and video signals; however it results in less than optimal audio output. This 4 port HDMI switcher separates the audio signal from the HDMI interface and transmits it to an amplifier by SPDIF or coaxial (RCA). IR remote included.

- 4 x HDMI inputs, 1 x HDMI output with coax and SPDIF audio output
- HDMI 1.3b compliant
- HDTV 1080p resolution
- Amplifier bandwidth 2.25Gbps/225MHz
- Dimensions: 155(W) x 70(D) x 23(H)mm

AC-1625 WAS $119.00

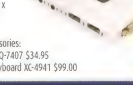
$99.00

SAVE $20.00

Remote PC Control Over Ethernet Adaptor 1080p

new

Want to play games, browse the net or watch the footy on your TV when the computer is in another room? This adaptor allows all of the above over a simple Ethernet connection. It features 2 x USB ports to connect a keyboard/mouse for remotely controlling a PC and 2 x 3.5mm sockets for audio and microphone input. Output is to DVI which may require an adaptor for connection to your flat panel TV.



- Supports Windows XP, Vista, and 7
- Dimensions: 120(L) x 57(W) x 21(H)mm

XC-4976

Recommended accessories:
DVI to HDMI Cable WQ-7407 $34.95
Wireless Trackball Keyboard XC-4941 $99.00

$149.00

Cat5 Video/Audio Extenders

These allow you to greatly extend your cable range using conventional Cat 5e cable, enabling you to extend the propagation distance or pipe your AV signals over conventional network cable runs. Two types available for complete flexibility:

Composite Video & Audio Cat 5 Extender

QC-3680 WAS $39.95
NOW $29.95 SAVE $10.00

Component Video & Digital Audio Cat 5 Extender

QC-3684 WAS $49.95
NOW $39.95 SAVE $10.00

FROM **$29.95**

All Savings are based on Original RRP
Limited stock on sale items.

Stereo DAB+ FM Radio

Still got an analogue radio? Upgrade to the infinitely superior DAB+ format for instant station selection, digital clarity, crystal clear stereo sound, zero interference as well as song and artist information on a bigger range of stations. 6 x AA batteries required or use the included AC adaptor.

- DAB+ or FM
- 10 station presets
- Clock and alarm
- 3.5mm headphone outlet
- 2 x 2WRMS output
- Dimension: 220(W) x 110(H) x 100(D)mm

AR-1756

$89.00

5.8GHz HDMI Sender with Remote Extender

Not cheap, but definitely the best. If you want to send a wireless high definition HDMI signal, this is the product for you. Simply connect the transmitter to the HDMI equipped TV in the remote location. This device lets you enjoy the benefits of watching Pay TV in the bedroom in full-HD quality without expensive cabling and installation. Includes IR sender/repeater.

$399.00
SAVE $100.00

- IR remote extender built-in
- HDCP 2.0 and CEC compliant
- HDMI 1.3 compliant
- Up to 1080p/60Hz video resolution (full HD)
- On-screen status display
- Dimensions: 180(L) x 140(W) x 39(H)mm

AR-1875 WAS $499.00

Crystal Radio Kit

Build it Yourself!

Enjoy AM broadcasting without using battery or other power sources. Ideal for entry-level students or hobbyist with little electronics experience. Includes circuit explanation.

- Kit supplied with silk-screened PCB (81x53mm), crystal, pre-wound coil, earphone and all components.

KV-3540

$12.95

Mounting Brackets

Our range of universal LCD, plasma and LED TV brackets are ideal for most installations.

- Models available to suit LED/LCD/Plasma TVs from 23 to 60"
- VESA standard compliant
- Solid steel construction
- Mounting hardware and instructions included

3 of our top selling models:

FROM $49.95

Slimline LCD/Plasma/LED TV Bracket

- Suits TVs from 32 to 60" up to 80kg
- Projecting only 10mm from the wall
- Spring-loaded cleats locks

CW-2823 $49.95

CW-2823

Plasma TV Wall Bracket 180 Degree Swivel

- Suits TVs from 32 - 60" up to 80kg
- Tilt range is ±15°, the extension arm is 660mm long
- Allows installation on 450 or 600mm stud centres

CW-2825 $149.00

Plasma/LCD Bracket 45kg

- Suits TVs from 23 - 37" up to 45kg
- Mounts flat or at fixed 5° angle
- Safety lock for security

CW-2826 $59.95

CW-2826

HDMI Type A Plug to Type D "Micro" Plug Lead 2m

new

HDMI Type D or "Micro" plug has been designed for full HDMI output from the smallest of portable devices. The plug supports HDMI version 1.4 with Ethernet and is capable of transferring full 1080p signals while being smaller than a micro USB plug.

- Cable Length: 2m
- Type D plug: 6(W) x 2(H) x 6(D)mm

WQ-7911

$44.95

TV Amplifiers

TV Signal Splitter

Boost your TV signal indoors. The antenna lead is plugged into the amplifier, and there are two outputs for two TVs, both which have a 12dB boost. One outlet can be used for FM stereo if desired. Runs on 240VAC mains, and includes a LED power indicator. Australian made.

LT-3288

$49.95

Indoor TV Amplifier Splitter

This unit is an analogue and digital television splitter/amplifier for use in multiple receiver applications. The amplifier has F type input/output connectors and features variable gain on the VHF band. It operates from 240VAC and is mounted in a white ABS housing with integral mounting lugs.

- Frequency range: 40 - 860 MHz
- Size: 60(W) x 40(H) x 85(L)mm

LT-3287

$99.00

new

Digimatch UHF/VHF Diplexer with DC Bypass

To install a VHF and a UHF antenna on the same cable, a diplexer like this one is required. Easy installation and the cable entry is sealed against the weather.

- HDTV compliant
- F connections for faster installations
- Fully screened and weatherproof
- Dimensions: 112(W) x 108(H) x 35(D)mm

LT-3082

$29.95

Professional VHF Wireless Microphone System

A professional wireless VHF microphone system with enhanced signal reception. Ideal for performers on the go, churches or halls etc. Includes 2 microphones, 1 wireless unit, and plugpack. Microphones require 2 x 9V batteries (not included).

- High-precision quartz crystal locked frequency
- 12 hour battery life
- Up to 80m range
- Dimension:195(L) x 145(W) x 42(H)mm

AM-4071

$99.00

new

Also available:

Lapel Mic Channel A AM-4057 $29.95
Lapel Mic Channel B AM-4059 $29.95

Audio Converters

Digital to Analogue Audio Converter

Connect a coaxial or optical (Toslink) audio source to this device and it will output to R/L composite analogue. Useful for connecting DVD/Blu-Ray players to displays or audio equipment that have no digital audio input.

- Integrated digital interpolator filter and D-A converter
- Stereo audio inputs
- Dimensions: 42(W) x 40.5(D) x 22(H)mm

AC-1603 WAS $69.95

$59.95
SAVE $10.00

Analogue to Digital Audio Converter

Convert a stereo analogue audio signal to coaxial and Toslink outputs simultaneously. It also supports uncompressed 2-channel LPCM (Linear Pulse Code Modulation) digital audio signal output with sampling rate at 48kHz. Both optical fibre and coaxial cables connected to the outputs of the unit can be run up to 5 metres whilst still providing a dependable and quality audio signal transmission.

- Audio delay (150 min-seconds)
- Noise free transmission
- Easy to install and use
- Power: 5VDC power adaptor included
- Dimensions: 67(W) x 50(D) x 23(H)mm

AC-1611 WAS $79.95

$69.95
SAVE $10.00

Digital Indoor/Outdoor Antenna

With its contemporary space saving design enables it to be mounted on a wall - great for apartments and those with minimal space. AC adaptor included.

- Frequency: VHF - 174-230MHz, UHF - 470-862MHz
- Antenna gain: 10dB
- Total gain: 40dB
- Dimensions: 502(L) x 235(W) x 76(H)mm

LT-3137

$99.00

Digital Is Coming

Buy a Gift Card Today!

AV/RF Modulator

Got an old telly with no AV inputs? No problem. Modulate the AV signal from S-Video or composite video signal and convert it to RF that you can connect straight to the antenna input as a UHF signal.

- Mains plugpack included.

LM-3879 WAS $74.95

$64.95
SAVE $10.00

www.jaycar.com.au

Limited stock on sale items.

All Savings are based on Original RRP

Jaycar Electronics
Better. More Technical.

Energy Saver!

Mains Power Meter

How much does that device cost to run? This unit plugs into a normal power point and turns it into a real-time power monitoring outlet. You can enter the local price of your electricity and the meter will tell you exactly how much the appliance is costing to run.
MS-6115

$19.95

Mains Standby Power Saver with IR Receiver

Save on energy bills and reduce your carbon footprint. Eliminates the needless power consumed by appliances when they are in standby. Once it detects that they are in standby mode, it will switch them off completely after a short delay. Switching all your appliances on again is as simple as pressing the on button on the remote control.

- Dimensions: 128(H) x 65(W) x 40(D)mm

MS-6146

$39.95

Wireless 3-Outlet Mains Power Meter

Simply plug an appliance into each sender unit, enter local electricity price and monitor the usage on the LCD receiver unit. Monitor the cumulative usage via the memory as well as the greenhouse gas emissions. It also has a clock and alarm function.

- Frequency: 433.92MHz
- Transmission range: 30m
- Receiver requires 3 X AA batteries

MS-6116

$79.95

Power Kits

Battery Zapper Mk III

The popular battery zapper kit has gone through a couple of upgrades and this is the latest easier-to-build version. Like the original project from 2005, it attacks a common cause of failure in lead acid+ batteries: sulphation, which can send a battery to an early grave. The circuit produces short bursts of high levels of energy to reverse the sulphation effect. The battery condition checker is no longer included and the circuit has been updated and revamped to provide more reliable, long-term operation. It still includes test points for a DMM and binding posts for a battery charger.

- PCB with solder mask and overlay
- All electronic components
- Screen printed machined case
- 6, 12 & 24VDC

Note: Not recommended for use with gel batteries
KC-5479

$79.95

Voltage Regulator Kit

This handy voltage regulator can provide up to 1,000mA at any voltage from 1.3 to 22VDC. Ideal for experimental projects or as a mini bench power supply etc.

- Kit supplied with PCB and all electronic components.

KC-5446

$16.95

3W LED 120 Lumens Tactical Torch

Bulletproof machined aluminium construction and O-ring sealed for all the rigours of professional work. The tailcap has a tactical switch suitable for military, law enforcement and security work. Requires 3 AAA batteries.

- Output: 120 lumens
- Size: 148(L) x 34(Dia)mm

ST-3399 WAS $19.95

$14.95
SAVE $5.00

Dual Battery Controller

This unit will charge both your main and auxiliary batteries when the engine is running and automatically isolate the engine battery when you stop. This lets you run fridges & lighting etc. from the auxiliary and preserve the engine battery for starting.

- 12 - 48 volt operating range
- 70 amp current capacity
- Size: 83(W) x 114(L) x 79(H)mm
- Dual battery support
- -40°C to 80°C operating temperature
- 0.9VDC voltage drop @ full load

MB-3670 WAS $119.00

Bargain of the month!

$99.00
SAVE $20.00

FREE LED Keyring Torch (SP-3395) For Every Purchase!

Slimline LED Book Light

Read comfortably without disturbing those around you. The light has two brightness levels and uses three super bright Light Emitting Diodes to flood your page with light and make reading a breeze.

- Compact and lightweight
- Batteries included
- Size: 40(W) x 105(L) x 10(D)mm

ST-3980 WAS $12.95

$6.95
SAVE $6.00

LED Torch Kit

Configure the light in any of three different ways: a hand-held torch, headlamp or a handy lantern. The head torch comes with its own battery pack and head band and the lantern makes the ideal tent light for camping. Lanyard and tripod included.

- Requires 1 x QR123A, 2 x AA batteries
- Output 120lm
- Torch 98(L)mm

ST-3391 WAS $69.95

$49.95
SAVE $20.00

Solar Powered LED Garden Lights

Save energy with one of these solar spotlights!
When darkness falls, the spotlight switches on automatically. They use high-powered LEDs and a built-in solar panel to charge the internal batteries during the day and allows the system to operate during the night.

Solar Powered LED Spotlight with Passive Infrared Motion Sensor

- 30 LEDs
- Illumination duration: 20, 40, or 90 sec. PIR controlled
- PIR Sensing range: 15 metres

SL-2718 WAS $99.00

$69.00
SAVE $30.00

Solar Powered LED Spotlight

- 30 LEDs
- Illumination duration: 10 hours

SL-2716
WAS $149.00

$99.00
SAVE $50.00

Solar Powered LED Garden Spotlight

- 11 LEDs
- Illumination duration: 10 hours

SL-2714 WAS $59.95

$49.95
SAVE $10.00

Wireless 3 Outlet Mains Controller

Simply plug in any mains appliance rated up to 10A and use the remote to turn each one on or off individually, or control all of them together. One of the outlets also has an LED night light that's also operated with the remote. Not just for couch potatoes, it also has real benefits for the elderly or disabled.

- 433MHz
- Remote battery included
- Remote measures: 125(W) x 45(H) x 17(D)mm

MS-6142

$44.95

Spare Mains Outlet with Light MS-6143 $17.95
Mains Outlet/Night-Light with Remote MS-6145 $24.95

new

LED Battery Voltage Indicator Kit

This tiny circuit measures just 25mm x 25mm and will provide power indication and low voltage indication using a bi-colour LED. The LED will be green when above the set point & red when below. The set point is adjustable using a trim-pot. The circuit is suitable for equipment powered from about 6-30VDC. With a simple circuit change, the bi-colour LED will produce a red glow to indicate that the voltage has exceeded a preset value.

- PCB, bi-colour LED and all specified electronic components supplied

KA-1778

$9.95

SLA Battery Health Checker Kit

The first versions of the battery zapper included a checker circuit. The Mk III battery zapper (KC-5479) has a separate checker circuit - and this is it. It checks the health of SLA batteries prior to charging or zapping with a simple LED condition indication of fair, poor, good etc.

- Overlay PCB and electronic components
- Case with machined and silk-screened front panel

KC-5482

$79.95

Better, More Technical

All Savings are based on Original RRP
Limited stock on sale items.

To order call 1800 022 888

High Quality 5.5" Electrical Shears

With serrated blades and insulated handles, these shears offer impressive cutting ability. Ideal for cutting insulation, heatshrink, spaghetti and light duty hook-up wire.

TH-1758

$6.95

Buy 2 for $9
Save $4.90

10-in-1 Rotary Pump-Action Screwdriver

Just like a .38 Special, this screwdriver has a rotary magazine that stores the bits. When a different bit is required, rotate the magazine, pump the reloading action and the new bit is inserted into the ratchet head ready to go. The handle stores 4 reserve bits and 8 other bits are included, but you can add any 4mm hex drive bit if needed.

- PH: 00, 0, 1, 2
- Slotted: 1.5, 2, 3
- Torx: T5, T6, T8, T10
- Dimensions: 168(L) x 26(Dia)mm

TD-2108 WAS $14.95

$9.95

SAVE $5.00

Micro Engraver

Engrave your valuables for security or insurance. The tiny diamond coated tip spins at 10,000 RPM so you can personalise tools, sporting gear, toys, put security IDs on valuables etc. Engraves glass, ceramics, metals and plastics. Batteries and case included. Tip is replaceable.

- Size: 160(L) x 15(Dia)mm

TD-2468

Replacement tip sold separately TD-2469 $6.95

$19.95

Windscreen Mount Suction Bracket for iPhone® 4

Use this handy bracket to mount your iPhone®4 on the windscreen where it's easily accessible, the strong 80mm diameter suction mount will keep it securely attached. The ball and socket joint enables positioning for maximum effectiveness.

HS-9008

Caution: The use of windscreen-mounted devices is illegal in some states, so check with your local traffic authority before using this device. Always ensure it is mounted so that it does not obstruct your view or cause a distraction.

$19.95

Gaming Console Tool Kit

If you have ever attempted any repair or improvement on your gaming console, you know that the right tools can make the difference between a good experience and a bad one. Everything you need to get into your gaming console & accessories. Includes tools for pretty much every console and handheld on the market today - Wii®, X-Box®, Playstation® etc. Carry case included. See website for contents.

TD-2109

$29.95

30 Piece Electronic Tool Kit

An electronic tool kit with all the essentials - cutters, pliers, Phillips head, slotted, Pozidriv, nut drivers etc. screwdrivers etc. Ideal kit for the computer service industry or IT. See website for full contents.

Case size: 210(L) x 140(W) x 38(D)mm

TD-2107

$29.95

For Your Solder Needs!

60W Lead-Free Soldering Station with LCD Panel

This excellent soldering station is particularly suited to lead-free soldering and is just as capable with ordinary leaded solder. The soldering pencil is fitted with a soft insulated rubber grip and has a silicon rubber sheathed power cable. Mains operated.

- Microprocessor controlled
- Temperature range 160°C to 480°C
- Set and actual temperature display

TS-1390

$179.00

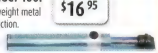
200g Solder Roll

0.71mm 60/40 solder on a 200g roll

NS-3005

$10.95

Metal Desolder Tool



Made from lightweight metal and has strong suction.

TH-1862

$16.95

Solder Flux Gel 10g Syringe

A mildly activated, resin-based flux formulation developed for a wide range of applications, leaving a pin-probable residue. Very low post-process residue, which remains clear and probable even at the higher temperatures required for lead free solders.

- 10g syringe
- Superior wetting
- Suitable for lead-free solders
- Reduces or eliminates voiding

NS-3039

$19.95

Travel Essentials!

Digital Luggage Scale

Pack one of these on your next trip and avoid nasty surprises at the check-in counter.

- Requires 2 x AAA batteries
- Capacity: 40kg
- Tare and auto-off
- Backlit LCD
- Overload and low battery indication
- Size: 122(L) x 85(H) x 25(W)mm

QM-7232

$19.95

40W Portable Folding Solar Panel

Excellent for your next camping, 4WD or boating trek, this fold away solar panel and charging kit allows you to easily charge your batteries (not included) allowing you to run power, lights, TV etc wherever you stop. Each model features alligator clamp connections on a 4m lead, has the charge controller included so you can connect directly to your battery without fear of over-charging, and is supplied with a heavy duty metal carry handle and latches, plastic protective corners and a durable nylon carry bag.

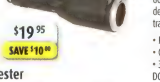
Dimensions:

- Open: 840(W) x 420(H) x 36(D)mm
- Folded: 420(W) x 420(H) x 73(D)mm

ZM-9132

$399.00

Universal GPS/PDA Car Charger



Ideal for powering a GPS or other mobile device. This handy adaptor plugs into any 12 or 24V cigarette lighter socket and provides 5VDC output. It also has an auxiliary cigarette lighter socket so you can use other devices while it's in use.

- Lead length 1.2m

MP-3046 WAS $29.95

$19.95

SAVE $10.00

Alcohol Breath Tester

It measures up to a blood alcohol level of 0.2‰. Response time is less than 8 seconds - all you do is wait about 10 seconds then blow into the sensor to give a reading in blood alcohol percentage or mg/litre. Requires 2 x AAA batteries.

- Compact purse or glove box size
- <8 second response time
- Backlit LCD
- Dimensions: 103(L) x 37(W) x 19(H)mm

QM-7298 WAS $29.95

$24.95

SAVE $5.00

Please note: this product is intended to give an indicative reading only and is carries no guarantee of accuracy. Jaycar accepts no responsibility for any consequence arising from the use of this device.

38 Ch Rechargeable Handheld 0.5W CB with Torch

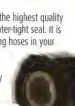
Perfect for camping, bushwalking and road trips, this CB has a built-in LED torch with 3km range and up to 30 hours battery life. It does all the normal CB functions and includes desktop charging cradle, AC adaptor, two transceivers and batteries.

- Power output: 0.5W
- Charging time: 6 hours
- 38 channel

DC-1007

$69.95

Silicone Rescue Tape



Rescue tape is a self-fusing tape made of the highest quality materials for a permanent air-tight and water-tight seal. It is designed for quick plumbing repairs, sealing hoses in your car/truck/boat, coating the ends of rope, wrapping tool handles, emergency o-ring seals or to insulate electrical wiring. Tightly wrap the tape for a quicker bond. Resists fuels, oils, acids, solvents, salt water, road salt, UV rays.

NA-2829

$19.95

www.jaycar.com.au

Limited stock on sale items.

All Savings are based on Original RRP

Jaycar Electronics

Better, More Technical

Micro Solar Car Racer

Don't let its miniscule size fool you! Shine a lamp on its solar panel and watch it travel across your desk. Shine a higher powered torch on it and you'll see it take off at a surprisingly furious pace. Adjust the front wheel steering so it goes around in circles. Comes in its own see-through screw case. Suitable for ages 8+

- Dimensions: 31(L) x 20(W) x 15(H)mm

GT-3750 WAS $14.95

$9.95
SAVE $5.00

Wireless USB Trackball Remote Control for PC

The trackball works as a mouse and you can type numbers or text in the same way you do with a mobile phone. It also has quick-launch keys, plus controls for multimedia use - play, pause, record etc. You can also program macros or single commands into any key. No software or drivers needed - just plug in the USB receiver. Requires 2 x AA batteries.

- 2.4GHz 10 metre range
- 19mm optical trackball & mouse keys
- USB dongle receiver
- Microsoft Windows XP MCE/ Vista compatible
- MCE hotkeys
- Dimensions: 180(L) x 50(W) x 30(H)mm

XC-4940 WAS $89.00

$69.00
SAVE $20.00

Interactive Music Quiz

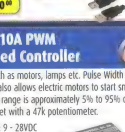
Test your family and friends' music knowledge with this interactive music quiz that you control! Game options include 'name that track', 'beat the intro', 'name the artist' and 'sing the next line'. Or make up your own game - the possibilities are endless!

- Speaker console with four team buzzers and LCD points display
- Quizmaster controller with music start/stop button, points buttons, crowd sound effects, three music distortion buttons and volume control
- MP3 player (not included) connection to the Quizmaster controller
- Requires 3 x AA batteries
- Suitable for ages 8+

GE-4233 WAS $39.95

$29.95
SAVE $10.00

7" USB Plug and Play LCD Monitor



Want more screen real estate and don't want the hassle of a big bulky secondary monitor that needs its own power supply and display cable, then this USB monitor is perfect. It's great if you're busy playing a game and still want access to your IM program like MSN or Skype. The screen has a nifty little rotatable stand and the display can be adjusted accordingly for portrait or landscape view.

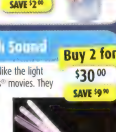
- Compatible with Windows 2000/XP/Vista/7
- Dimensions:188(L) x 114(W) 35(H)mm

QM-3748 WAS $269.00

Plug and Play!

$219.00
SAVE $50.00

Fan with detachable Water Spray



Ideal to keep in your sports bag to use after a big workout. Can also be used as a normal fan by removing the water bottle. Runs on 2 x AA batteries (available separately).

GH-1073 WAS $8.95

$6.95
SAVE $2.00

Battery Discharge Protector

NEW

Protects a car battery from total discharge by switching off appliances such as fridges and TV sets before the battery voltage drops to an unrecoverable level. When battery voltage is re-established by recharging, it switches appliances on automatically. The interrupting voltage is adjustable from 10.4 to 13.3 VDC.

- Operating voltage: 12VDC
- Max. switching current: 20A
- Interrupting voltage: 10.4 - 13.3VDC
- Resetting voltage: approx. 0.8V (± 0.3V) above interrupt voltage
- Current consumption: < 0.7mA when OFF, < 1.6mA when ON
- Dimensions: 87(L) x 60(W) x 32(H)mm

AA-0262

$39.95

9 - 28VDC 10A PWM Motor Speed Controller

NEW

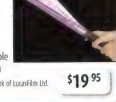
Control DC loads such as motors, lamps etc. Pulse Width Modulation (PWM) also allows electric motors to start smoothly at low RPM. Control range is approximately 5% to 95% of maximum output, set with a 47k potentiometer.

- Operating voltage: 9 - 28VDC
- Max. current carrying capacity: 10A with heatsink, 5A without heatsink
- Control range: < 5% to > 95%
- Control mode: Pulse Width Modulation
- Dimensions: 86(L) x 60(W) x 33(H)mm

AA-0349

$69.95

LED Sabre With Sound



This unit sounds uncannily like the light sabre seen in the Star Wars™ movies. They have the swooshing sound when held stationary and make that famous noise when they are waved around. They also change colours & glow quite brightly.

- Extremely light and durable
- Size: 710(L) x 48(Dia)mm

'Star Wars' is a registered trademark of LucasFilm Ltd.

GF-3520

Buy 2 for $30.00
SAVE $9.90

$19.95

DVR Kits with Colour Cameras

Ideally suited to smaller surveillance installations around the home or office. These 4 channel systems can store over 150 hours of video on the 320GB HDD. Recorded video is indexed in an event log and can be viewed via a computer or external monitor. Complete with weather resistant IR cameras, cables, remote control and mains adaptors.

QV-3020 shown

FROM $379.00

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- 1 x composite video output
- MJPEG compression
- SATA hard drive interface
- 320GB Seagate SV35 Surveillance Hard Drive

Camera
- CMOS sensor, 350TV lines
- Inbuilt infrared illumination
- Day/night operation
- Spare camera available separately QC-3239 $59.95

Two models available:

4 Channel DVR Kit with 2 IR Cameras
QV-3020 WAS $499.00 NOW $379.00 SAVE $120.00

4 Channel DVR Kit with 4 IR Cameras
QV-3024 WAS $599.00 NOW $499.00 SAVE $100.00

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SERVICEMAN'S LOG

Thanks for the dodgy memory – *not*

Buying at the lowest price doesn't always save you money, especially if the person selling you the gear doesn't know what they are doing. That certainly applied to a laptop I encountered recently – you won't believe what they did to it.

Items Covered This Month

- Laptop memory butchery
- A dangerous fan
- Light dependent diode
- Playing doctors & nurses
- GMC/Homelite 1kV generator

It's not unusual for people to reject our quotes for new computers and instead buy from the big retail stores. That's because there is no way we can match the store's buying power, although we can offer superior support. Despite that, many of our clients do choose to pay a bit extra just to have good service back-up.

However, loyal customers become scarce in times of recession and I can't blame anyone for going elsewhere and saving what can often be a few hundred dollars on a new PC. In one such case, a client procrastinated over a laptop sale and after a lot of thought, he finally decided to go elsewhere and pay less. He even managed to better the deal there by getting more RAM installed at no extra charge, which many shops will do these days in order to secure the sale.

Unfortunately though, it didn't all go smoothly for him and a few months later he was back in our reception area, bemoaning the service he'd received and eating crow. The machine was playing up and he was willing to pay whatever it took to get the thing going properly again. And he swore (literally) that he'd never go back to that other place.

The symptoms were that it would spontaneously shut down, sometimes with movement or a tap on the side, sometimes without. He had taken it back more times than he could remember and after much gnashing of teeth and wringing of hands, they had replaced the hard drive and motherboard. This didn't fix the problem though and the laptop still continually shut down.

So why didn't they just do what I would have done and given him a new one? Experience has shown that you sometimes just get a bad egg and no matter what you do, it will never work properly. In the end, it is really no skin off our (or their) noses, as the manufacturer simply replaces it in good faith and take cares of the old one, probably by throwing it into a skip.

Anyway, we accepted the challenge, more out of professional curiosity than anything else. On testing, sure enough, any sudden movement would

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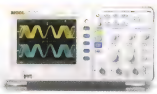

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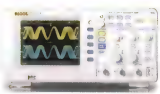

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~SO SHE TOOK THE WHOLE THING "OUT THE BACK"

cause the thing to shut down. I didn't even have to hit it, although I'll bet it had been hit in frustration quite a few times in its short life! Instead, simply shaking it lightly but firmly resulted in a shutdown.

Obviously something was loose somewhere, but what? Was it the battery connection? It happened whether the battery was plugged in or not, so that was out. What about the hard drive connector? The motherboard and hard drive had been replaced, so that also seemed unlikely.

I stripped the machine down to its bare bones and set it up to run without the case and covers. After firing it up, I went around and lightly tapped everything I could access with the butt end of a small screwdriver. I also tried twisting the screwdriver's shaft back and forth between my fingers so that the fluted handle "rattled" lightly against the edges of the motherboard and the chassis.

But despite all this tapping and induced vibration, nothing could make it fail. And so, with much juggling of parts, I turned the whole caboodle over so that I could repeat the exercise on the bottom side of the board. The most prominent objects on this side were the memory modules and one tap on the top module shut the machine down instantly. Ha-ha!

By this stage, I was cursing myself for not taking the memory out and trying it before stripping the machine down (and wasting so much time). Anyway, I removed the module and tried again. This time, it was as steady as a rock, so I reassembled the machine and ran it without that module. I couldn't fault it so I put the memory back in only to have the machine immediately fail again.

So it was a faulty memory module rather than a contact fault but why such strange symptoms? I had seen nothing like this before due to faulty memory.

I took a closer look at the module and something didn't look quite right. The end closest to the locating notch looked out of square somehow, so I popped the other module and placed them side-by-side for comparison.

That's when the penny dropped – they might have looked the same to the casual observer but these were two different types of RAM. The sticker on the one I'd just removed (which worked) said DDR2 533, while the other was something else. Oddly, its label had been removed but by comparing it to other modules I had in the drawer, I soon discovered that it was probably PC2700/DDR333 RAM or something similar.

However, as close as the two types are to each other in terms of size and locating notch position, DDR333 RAM shouldn't fit in the slot since it is slightly too long at the locating notch end. In this case though, someone had filed the end of the module in order to make it fit the slot and that could only have been the people who fitted it in the first place.

I called the client and told him what I had found. He then told me that the store member who had offered the extra RAM had selected a module off the shelf. However, she then had trouble fitting it to the laptop at the counter, so she took the whole thing "out the back".

She subsequently returned after about 10 minutes with everything buttoned up and apparently seemed a bit flustered while finishing off the sale. When my client got his machine home and booted it up, it showed 2GB less memory (in System Properties) than it should have. He called the shop and they mumbled some drivel about a Vista "bug" not showing RAM amounts properly but he could rest assured the RAM was in the machine and working.

Well, as we now know, it wasn't. By some miracle, when at rest the module's contacts missed all the vital points. However, when the laptop was bumped, something made contact and the machine instantly shut down.

Fitting the correct type of memory cured the problem and the machine now displayed the correct amount of memory. So much for the so-called Vista memory bug! I doubt that my client will ever return to that particular store – at least not to buy a computer.

A dangerous fan

When you are a lowly first or second-year aircraft avionics engineering apprentice, no-one really trusts you with anything important. It takes ages to get used to the constant close inspection of every little thing you do by other apprentices, fellow engineers and the hawk-eyed quality-assurance technicians, especially if you are used to working alone in a home workshop.

Of course, all those inspections are critical in the aircraft repair business because lives depend on every nut, bolt and a zillion and one other components being exactly right. There are no grey areas – something is either 110% correct or it is wrong and needs to be re-done until it is right.

The following story comes from the third year of my 5-year (10,000 hours) apprenticeship. By then, I knew enough to get into trouble, though finally most of the guys I worked with were beginning to trust that I could actually do the job to their exacting standards. However, I was still an apprentice and being physically small in stature, I got the worst of the "hairy" jobs – those special assignments usually delegated to the lowest-ranking member of the team.

Such jobs included cleaning bird-strike debris from engines, checking wiring looms inside extremely tight and dirty spaces and other equally grim tasks. One such job, which wasn't too bad because it didn't involve being fitted with breathing gear and/or crawling around knee-deep in av-gas, was squeezing in behind the equipment mounting racks in the E&E (Electronics and Equipment) bay, to carry out maintenance, install new hardware or to simply inspect and ensure all the wiring was squared away.

The E&E bay is a very small room that's usually situated aft of the nose-wheel bay but before the wing/cargo bay areas. This is where much of the avionics gear lives and easy access to everything is a must for quick changes should a unit become unserviceable. Even so, getting to this gear can sometimes be a tight squeeze.

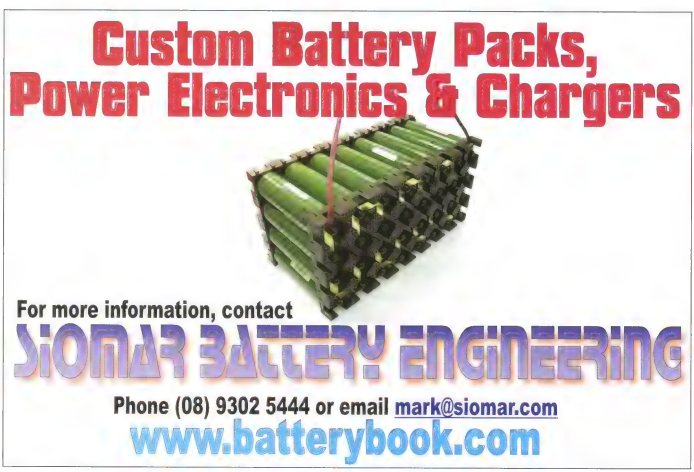
Generally engineers needing to replace equipment stand on a special gantry that puts the top half of their body inside the bay, allowing them arms-reach access to most of the gear. However, sometimes components situated on the back of the various racks need attention, so some small-framed engineer is usually rustled up and requisitioned for the job.

Unfortunately, due to my (then) slim stature and position in the pecking order, I was the one who usually "volunteered" for the mission. However, when it came to the E&E bay, I didn't mind all that much to be honest. I never really knew the meaning of claustrophobia until I kitted up for working in wing tanks – they are very dark, very tight and very dangerous because of fumes and the ever-present possibility of static discharge unless special precautions are taken. In the E&E bay though, none of this was a worry, although access in planes such as a Boeing 737 could be tight.

One particular day, I did the work required, which involved checking the general integrity of all the racks, connectors and wiring looms and all went swimmingly until I went to extract myself. This involved lying on my back and pushing myself forwards with my boot heels while using my arms to push on the racks above me – at the same time being careful not to disturb anything. However, as I reached up, I suddenly felt a very sharp pain in my thumb and it was knocked forcefully away from me. I brought my hand down and the end of my thumb looked like a cauliflower floret dipped in tomato sauce.

I barely remember exiting the bay but I do remember the look in my foreman's eyes as he took stock of the situation and led me off to the nurse's station.

It turned out that I had been unlucky.



Or more accurately, it had been a string of bad luck that had led to my right thumb now being shorter than my left. Subsequent investigations revealed that I had stuck my thumb into a high-speed, 100mm cooling fan. This fan was not a Boeing-standard item; instead, it had been designed by our Technical Services department. I went and asked the team responsible why this fan hadn't been covered.

Their reasoning was that because the fan was in such an inaccessible spot, a cover would have been an unnecessary expense. That was my first bit of bad luck. The next was that in the direction it was running, the steel blades of the fan should have pushed my thumb out of the way, perhaps giving it a good whack but not chopping it the way it did. However, it turned out that someone at some earlier time had caught something else in it, perhaps a screwdriver, and this had twisted and distorted the blade into a cutting edge.

As it was, the fan had to be replaced and this time the guys had a cover made for it which was clipped into place, ensuring something like this couldn't happen again. Understandably, I wasn't overly happy about the whole thing but it was my foreman who really took the people responsible to task over it. He couldn't believe that engineers of their calibre would forgo covering any fan, let alone a high-speed unit.

Not only that but he was also concerned that whoever damaged the fan previously had not reported it. While no one wants to get into trouble, in a safety-conscious environment like airline industry, reporting such incidents comes before anything else.

Uplifting experiences

Now for a couple of reader contributions. P. S. from Fremantle, WA is an elevator technician and he encounters some interesting situations in the course of his work. Here's why you should always wash your hands after servicing these devices . . .

The life of an elevator technician can see him performing a wide range of tasks. These include replacing hoisting ropes, servicing brakes, cleaning relay contacts on a 50-year old controller with hundreds of relays, fault-finding a machine with TTL logic gates or using a remote computer terminal to monitor the operation of a modern microcontroller-based system. And integral to all this is the requirement for the tradesman to have plenty of customer service savvy.

Sometimes an elevator will manifest a purely technical (and often elusive) fault, such as a machine that was commissioned while I was a final-year apprentice. It was a large high-speed lift with the DC hoist motor's speed regulated by a reference signal and feedback from a tacho mounted on the hoisting sheave. Unfortunately, it suffered from a nasty vibration in use but what was causing it?

On the CRO it was evident as a ripple on the feedback signal. So was it mechanical in origin, electrical or electronic? Furthermore, at the end of the day when we locked up the motor room and got in the lift to go home, it ran as smooth as silk.

The next day, the problem was back and the fault was finally tracked down when I applied a test probe to a terminal strip. As I did so, my hand shaded the light from a certain diode and the ripple disappeared.

It transpired that the temporary light we had rigged up in the motor room was introducing a 50Hz ripple into the system via this small-bead diode (a 1N4148 or similar). After all, PN junctions are light sensitive! At the end of the day, the ride was smooth because the light had been turned off. Moving this temporary light (it had been only centimetres from the diode) solved the issue.

Often vandalism or abuse results in an elevator "playing up". When I was cleaning and adjusting the door-lock contacts on a goods lift I asked the tradesman what was causing the corrosion and white furry coating over the components. Once I had completed the job he wised me up to the fact that customers coming out of the tavern on the floor above were sometimes busting for a pee and the corner where the elevator is located was a convenient place to relieve oneself. Hence the heavy corrosion (and why you should always wash your hands before smoko!).

On another occasion I arrived at a call-out for a passenger stuck in a lift at a railway station. By the time I arrived the occupant had got out but not before ripping off the control panel and urinating over it. He was fortunate that the control voltage was only 24V and that the 240V light and fan switches were more secure. The fact that he had done this in a glass lift in a public space further highlighted his crass stupidity!

Doctors & nurses

Sometimes the intent is less malicious. When a colleague was an apprentice in the UK, he was alerted to a lift that had stopped mid-floor. There had been numerous such stoppages with this particular system and in each case the lift would always restart sometime later but no cause could be found.

This time, luck was on his side. He just happened to be working on top of an adjoining lift when it stopped and on hearing suspicious sounds from the offending lift car, he came alongside and quickly stepped across. He then quietly opened the trapdoor in the roof of the lift to see a doctor and nurse had wheeled a bed into the lift. They had then flicked the stop switch off after it had moved a few metres (in the UK a toggle switch was provided instead of a pushbutton) and were proceeding to . . . well play doctors and nurses!

Replacing the toggle switch with pushbuttons solved the problem – at least as far as the lift technicians were concerned.

Often, as servicemen in other fields will testify, an intermittent fault will

Servicing Stories Wanted

We welcome reader contributions for Serviceman. It doesn't matter what the story is about as long as it's in some way related to the electronics or electrical industries, to computers or even to car electronics or electrics. We pay for all contributions published but please note that your material must be original. Send your contribution by email to: **editor@siliconchip.com.au** and be sure to include your full name and address details.

THEY HAD FLICKED THE TOGGLE SWITCH & WE'RE PROCEEDING TO PLAY DOCTORS & NURSES

test a technician's skill, patience and customer-service savvy. One elevator in a hotel had stopped for no apparent reason. After checking and resetting it, the machine could be run a hundred times without fail and then, a couple of nights later, the call would come in again.

The problem was found almost by chance. One day, when testing the lift, we noticed a brief flicker in the mains-voltage sensing relay as the hoist motor started, indicating a dip in the supply voltage. Testing indicated that the supply voltage was down and enquiries to the supply authority confirmed that they had dropped the voltage in the area from 250V to 240V just prior to the lift playing up.

A new voltage sensing relay set for a lower voltage resolved the issue.

GMC/Homelite 1kVA generator

This next story is from D. B. of Yorketown, SA . . .

A customer came in with a GMC/Homelite 1kVA generator that wasn't generating any power. I removed the automatic voltage regulator (AVR) unit and noticed that the black resin at one end was cracked. As a result, I slowly chipped away this resin using a sharp wood chisel and found that the Mosfet had split apart. This was replaced and the unit reassembled but there was still no power.

Next, I ran the generator and fed 12V to the rotor brushes. The unit now produced power, which proved that the problem lay in the AVR unit.

I removed the AVR once more and continued chipping away at the resin, while measuring as many component values as possible. Some resistors were destroyed during this process and others had their colour codes damaged. After removing all 24 components from the board, I decided to replace the lot with new parts as these would only cost about $15.

In the process, the 100µF 16V electrolytic capacitor was replaced with a 35V unit as the original had dried out and there is about 18V across it in operation. The rebuilt unit worked fine, so I fitted it into a small plastic box and mounted it on the front panel, beneath the fuel tank.

In the end, it was a very satisfactory outcome considering that I couldn't find any information on these AVR units. SC

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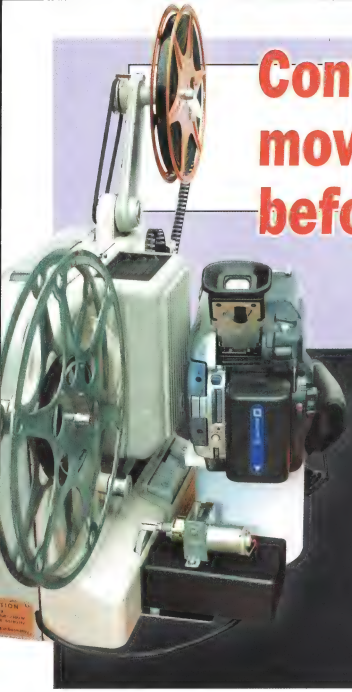


Convert your 8mm movies to DVD before it's too late!

You will need this projector speed controller

Do you have old family movies on film? Have you watched them lately? You may be shocked by how much they have deteriorated over the years. They need to be transferred to DVD before the film deteriorates to the point where it is unwatchable. Video conversion is not as straightforward as you might think but this simple project enables you to do it.

By JOHN CLARKE

IF YOU HAVE OLD family movies stored in some dark spot in the house, they are bound to be rotting away. If you doubt us on this point, better crank up your old projector and have look for yourself. You will be probably be horrified at the visible deterioration. You need to act now so that you can preserve them for posterity. Transfer them to DVD as soon as you can. As a bonus, this will make it easy for you to pass them on to other family members or relatives.

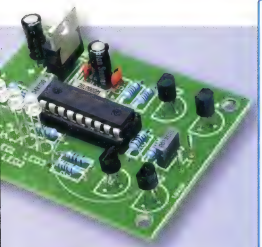
You also need to consider that your bulky, old film projectors will not last forever either. Spare lamps and parts are probably now quite expensive and hard to get. And apart from that, projectors are noisy, not easy to use and not many people are familiar with their operation. So there is no alternative really – you need to convert those movies to DVD before it is too late.

Converting to digital

There are many commercial enterprises that can restore film and transfer your old films to digital format. Such companies typically use quite sophisticated techniques for film-to-video conversion and these methods are described at **http://en.wikipedia.org/wiki/Telecine**

For home movies though, getting the job done commercially can be rather expensive. Fortunately, you can do the conversion yourself. It basically involves running the film through a projector and using a video camera to record the on-screen image. The resulting video can then be recorded to DVD via a computer or DVD recorder. If you don't already have a film projector, then check eBay for a secondhand unit. However, before you leap in, you will need a projector speed controller to get good results, otherwise film speed variations and synchronisation problems will give lots of flicker.

Let's now describe what you need to do.



The Speed Controller PCB carries a PIC microcontroller, three indicator LEDs and four transistors to drive a motorised pot. The shaft of the pot then drives the existing speed control knob on the projector.

The set-up for videoing a projected film image is shown in the photo on the facing page. As can be seen, the film is projected onto a screen and the video camera records the image. However, there are a couple of simple tricks to get good results.

First, the projector must be placed no more than about 250mm away from the screen, so that the video camera "sees" a bright image. This ensures that the camera operates at a relatively high luminance level for best image contrast and least picture noise. For the screen, good-quality white paper can be used.

Note that the recording also needs to be done in a darkened room to ensure optimum contrast. However, it's not necessary for the room to be completely dark.

Our experiments showed that good results can be obtained by setting the video camera to automatic focus and exposure. It may be possible to obtain better results by setting these controls manually in some cases, although this will very much depend on the film quality. If the film exposure varies widely, then a manual exposure setting on the video camera will not be suitable.

In our case, we used a Sony Digital 8 Video Camera Recorder which records onto tape. The resulting video signal was then captured on a computer and the titles added using Windows Movie Maker, after which it was burnt to a DVD.

Of course, many people will now have a more modern camcorder that records directly to digital memory. In that case, it's simply a matter of copying the file directly to a PC or to a DVD recorder.

Avoiding flicker

Flicker is the big problem and it is all to do with synchronisation.

Basically, the speed of the projector's motor must be set so that the projected film rate is synchronised with the video field rate of the camcorder. In practice, this means that the projected film frame rate must be a multiple of the video field rate. If this is not done (ie, the film frame rate is not synchronised to the camcorder), the recorded video image will flicker severely

The Australian PAL-B video standard specifies a frame rate of 25Hz. In practice, each frame is broken down into two fields for a total of 50 fields per second (see **http://en.wikipedia.org/wiki/PAL** for more details).

By contrast, standard-8 film is recorded at 16 frames per second (fps), while Super-8 films are generally recorded at 18 or 24 frames per second (refer to **http://en.wikipedia.org/wiki/8_mm_film**).

To synchronise with the 25Hz video field, the 16 fps for standard-8 film can be sped up slightly to $16^2/_3$ fps. This slightly increased speed is not particularly noticeable and gives a frame lock of 1.5 video fields for each film frame (ie, $16^2/_3 \times 1.5 = 25$).

Similarly, an 18 fps projector can be slowed to $16^2/_3$ fps to achieve synchronisation, while a 24 fps projector can be sped up slightly to 25 fps.

Locking the film and video rates prevents any flicker apart from the normal flicker associated with the film projection and the video field flicker. However, as noted above, the recorded video image will flicker severely if the film frame rate is not synchronised. When the film rate and the video field rate are very close to but out of lock, the recorded video picture will slowly fade in and out of brightness. The further out of lock they are, the faster the flicker.

Projector speed controller

The automatic speed control described here uses a sensor to monitor

Synchronising To The 25Hz Video Field Rate

Although a film projector may have a frame rate of 16 fps (for example), the film is not projected continuously. Instead, a mechanical shutter blanks out the projection for the period during which the film is progressed from one frame to the next. This frame progression occurs 16 times per second.

As a refinement, the shutter also provides film blanking at a faster rate than the frame rate. This provides a higher image repetition rate to reduce image flicker. As an example, a "Noris 8 Synchroner 100" standard-8 film projector (manufactured by Ernst Plank in Nurnberg) has three vanes on the shutter to provide an image rate of 3 x 16 or 48 frames per second.

When the projector speed is adjusted to $16^2/_3$ fps per second (to lock with a camcorder), the 3-vane shutter provides an image repetition rate of 3 x $16^2/_3$ = 50Hz. This will synchronise with the 25Hz video frame rate for the PAL system.

By contrast, super-8 projectors which run at 24 fps have a 2-vane shutter and this also provides a frame rate of 48 (ie, 2 x 24) frames per second. In this case, the projector is sped up to 25 fps to again provide a 50Hz rate.

The projector speed adjustment can either be done manually or automatically. Manual adjustment is achieved by watching the video recording via the viewfinder and adjusting the projector speed knob to maintain lock, based on the rate of picture fade in and out. As such, it requires constant attention from the operator and quickly becomes tiresome. It is also fraught with other problems.

The main problem is that it is not known whether the speed needs to be increased or decreased to reduce the fade-in and fade-out effect. Another problem is that the image will drift out of lock, with fading becoming noticeable, before any correction is made. Even a hint of slow fade-in and fade-out of the picture is quite noticeable in the recorded video.

For these reasons, it is far better to have an automatic speed adjustment system. This can then correct the projector speed before any fade-in and fade-out effects can be detected.

Parts List

1 PCB, code 13104111, 62 x 47mm
1 UB5 box, 83 x 54 x 31mm (optional)
1 motorised potentiometer (Altronics R2000).
1 20MHz crystal (X1)
1 DIP18 IC socket
1 30mm length of 0.7mm tinned copper wire
7 PC stakes

Semiconductors

1 PIC16F88-I/P microcontroller programmed with 1310411A.hex (IC1)
1 7805 5V regulator (REG1)
2 BC337 NPN transistors (Q1,Q2)
2 BC327 PNP transistors (Q3,Q4)
1 1N4004 1A diode (D1)
1 photo interrupter (Jaycar ZD-1901, Altronics Z1670)
3 3mm red LEDs (LED1-LED3)

Capacitors

2 100µF 16V PC electrolytic
1 100nF MKT polyester
1 10nF MKT polyester
2 33pF ceramic

Resistors (0.25W, 1%)

1 10kΩ
1 2.2kΩ
6 1kΩ
1 470Ω

Miscellaneous

Hook-up wire; 2-core shielded cable; aluminium sheet for motor bracket; screws, nuts & spacers

Checking The Projector & Correcting Pitch

Standard-8 film projectors are now vintage machines and will require checking to ensure that they are safe to use. In particular, check that the mains lead is safe and that the projector body is correctly earthed (you should get a zero ohms reading between the earth pin of the main plug and the projector's metal frame).

The projector depicted in this article had been left unused for quite some time and initially operated for several minutes when fired up. An small explosion somewhere within its workings then destroyed the lamp switch. It didn't take long to spot the problem – the suppression capacitor across the mains supply had exploded.

A 275VAC X2 MKP capacitor was used as a replacement but the problem could have been averted if this capacitor had been changed earlier.

Note that standard-8 film did not include sound. With super-8 there may be sound included but the audio recording will no longer be at the correct speed when the projector speed is locked to the video field rate. As a result, the pitch will be altered.

If this is a problem, the pitch can be corrected using Audacity (**http://audacity.sourceforge.net/download/**) or similar sound recording software, so that the sound appears more natural. Make sure that the file length is not altered when doing any adjustments though, otherwise the sound will be longer be in sync with the picture.

The processed sound file can be re-synced with the picture at the start of the DVD burning process.

the projector's shutter speed. This is compared to a reference frequency to derive an error signal which then controls a motorised potentiometer attached to the projector. The shaft of this motorised pot drives the projector's original speed control.

Any variation in the shutter speed from lock is corrected by driving the motor in one direction or the other, to rotate the projector's speed control knob.

A photo-interrupter is used as the detector and this is installed so that the shutter's blades pass through its slot. When the projector's speed is correct, the signal from the photo-interrupter will be at 50Hz.

If the photo-interrupter does not receive any signal (eg, when the projector is switched off to change the film reel), the Speed Controller immediately stops driving the motorised pot. This ensures that the projector's speed will be close to the lock speed when it is switched on again.

Speed control pot

As indicated, a motorised potentiometer is used to drive to the existing speed control knob fitted to the projector. Before fitting it, this motorised pot must be modified by removing its resistive element. This is done so that the shaft can rotate fully through 360°, ie, without the normal 270° end stops.

This means that the motorised potentiometer no longer functions as a potentiometer. Instead, we are using it purely as a motor (along with the pot shaft) to drive the projector's existing speed control knob.

Circuit details

Take a look now at Fig.1 for the circuit details of the Projector Speed Controller. In addition to the photo-interruptor, it includes a microcontroller (IC1), some indicator LEDs and four transistors (Q1-Q4) to drive the pot motor in either direction.

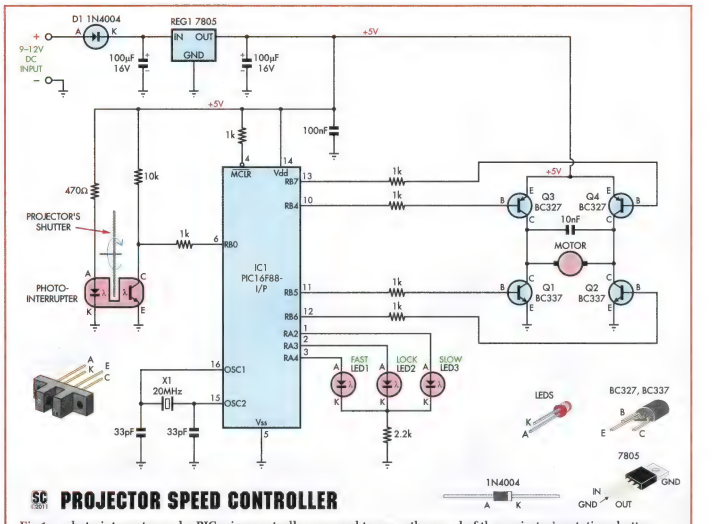
Microcontroller IC1 operates at 20MHz, as set by crystal X1. This ensures that the projector's frame rate is measured with sufficient accuracy for locking against the PAL 25Hz frame rate.

The photo-interrupter comprises an infrared LED and phototransistor mounted in a slotted enclosure. When IR light from the LED passes between the shutter blades, the phototransistor is biased on and the voltage at its collector is close to 0V. Conversely, when light from the IR LED is blocked by the shutter, the phototransistor turns off and its collector is pulled to +5V via a 10kΩ pull-up resistor.

IC1's RB0 input (pin 6) monitors the photo-interrupter signal. In operation, IC1 counts a 625kHz signal (derived from the 20MHz crystal oscillator) between every fourth rising edge voltage at RB0.

As previously stated, a 16 fps projector needs to be sped up to $16^2/_3$ fps. Assuming a 3-blade shutter, this will result in a 50Hz signal from the photo-interruptor. As a result, successive fourth rising edges will be 80ms apart and the 625kHz count will be 50,000.

If the count is greater than this, the projector's shutter rate is slower than 50Hz. Conversely, if the count is less than 50,000, the rate is faster than 50Hz. As a result, IC1 drives the motor in one direction or the other via transistors Q1-Q4. This either speeds up the projector if the count is greater than 50,000 or slows it down if the



PROJECTOR SPEED CONTROLLER

Fig.1: a photo-interuptor and a PIC microcontroller are used to sense the speed of the projector's rotating shutter blades. IC1 then compares this speed to a reference frequency and drives a pot motor via transistors Q1-Q4.

count is less than 50,000.

Counts within two of 50,000 (ie, between 50,002 and 49,998) are regarded as being in lock, so drive to the motor ceases. When this happens, the Lock LED (LED2) lights. By contrast, counts within 319 of 50,000 result in the motor being driven slowly with short pulses to adjust the projector's speed. In this case, the Lock LED lights along with either the Fast or Slow LEDs (LEDs1 & 3), depending on whether the projector speed is too fast or too slow. This indicates that the projector is being adjusted for speed but is close to the lock condition.

Finally, for counts greater than 319 either side of 50,000, the motor is driven at full speed and either the Fast or Slow LED is lit. The Lock LED is off during this time and remains off until the count gets to within 319 of 50,000.

It's much the same for super-8 film shot at 24 fps. In this case, the projector speed must be increased to 25 fps but unlike standard-8 projectors, super-8 projectors invariably employ a 2-blade shutter. This again means that the shutter blade frequency of 50Hz is necessary to achieve lock, so a count of 50,000 is necessary just as it is for 16 fps projectors.

Similarly, if an 18 fps (3-blade) projector is slowed to $16^2/_3$ fps, we again need a 50Hz shutter blade frequency (and a 50,000 count) to achieve lock. As a result, we can use exactly the same firmware in IC1 for all three cases. **There's no need to change the firmware to suit individual projectors.**

Driving the pot motor

IC1's outputs appear at RB7, RB4, RB5 & RB6 and these drive the motor in one direction or the other via transistors Q1-Q4 which are arranged in an H-bridge configuration. Q1 & Q4 are switched on to drive the motor in one direction, while Q2 and Q3 drive the motor in the other direction.

The motor is off when all the transistors are off, ie, with RB5 & RB6 both low and RB4 & RB7 both high. A 10nF capacitor suppresses any spikes across the motor terminals.

Power for the circuit is derived from a 9-12V DC supply rated at 100mA (eg, a 9V or 12V DC plugpack). Diode D1 provides reverse polarity protection, while REG1 provides a regulated 5V supply for the circuit.

Construction

All the parts except for the photo-interruptor and motor are mounted on a PCB coded 13104111 and measuring 62 x 47mm. This can either be housed in the same UB5 utility box that's used to support the motorised pot or it can be mounted inside the projector.

Fig.2 shows the parts layout on the PCB. Check the PCB carefully for any

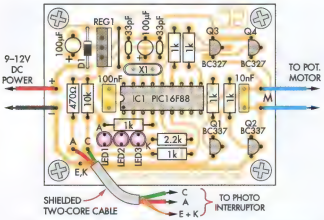


Fig.2: follow this diagram to assemble the PCB. Note that two different transistor types are used for Q1-Q4.

The PCB should take no more than about 30 minutes to assemble. Take care with component orientation.

defects, then check that the corner holes are drilled to 3mm. Seven PC stakes are used for all the external wiring connections and their holes should all be 1mm.

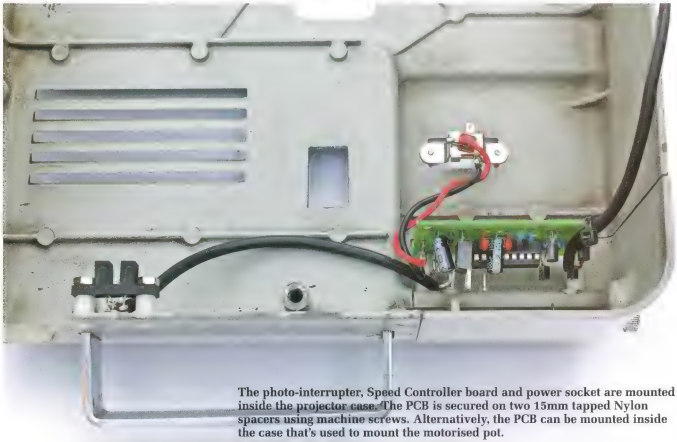
Begin the assembly by installing the single wire link (adjacent to REG1), then install the resistors. Check each resistor using a DMM before installing it – don't just rely on the colour codes as some colours can be difficult to read.

Diode D1 is next on the list and this must be orientated as shown. That done, install the capacitors, crystal X1, the IC socket and the PC stakes. Make sure that the electrolytics go in the right way around.

Regulator REG1, transistors Q1-Q4 and the three LEDs can now go in. These parts must all be orientated correctly. Take care not to get the transistors mixed up – Q1 & Q2 are both BC337 (NPN) devices while Q3 & Q4 are both BC327s (PNP).

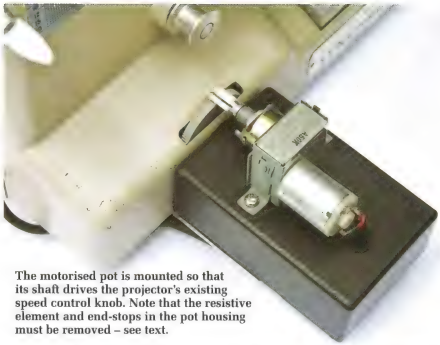
Note that if you intend mounting the PCB in the UB5 box, then the electrolytic capacitors and REG1 will need to be bent over to clear the lid. In particular, REG1 would have to be mounted with its leads bent at right angles, so that it lies over the adjacent capacitors.

On the other hand, if the PCB is to be mounted within the projector, this should not be necessary and the parts can be mounted as shown in the photos. In our case, we mounted the PCB inside the projector case on 15mm stand-offs and there was plenty



The photo-interrupter, Speed Controller board and power socket are mounted inside the projector case. The PCB is secured on two 15mm tapped Nylon spacers using machine screws. Alternatively, the PCB can be mounted inside the case that's used to mount the motorised pot.

The fast (F), lock (L) and slow (S) LEDs protrude through holes drilled in the projector housing, while the power socket for the speed controller board was fitted to an existing square cut-out.



The motorised pot is mounted so that its shaft drives the projector's existing speed control knob. Note that the resistive element and end-stops in the pot housing must be removed – see text.

of room for REG1 and the electrolytic capacitors. Be sure to install REG1 with its metal tab towards the adjacent 33pF capacitor.

The three LEDs can all be mounted at full lead length, so that their tops either protrude through the projector casing or through the lid of the box. Take care with their orientation – the anode is the longer of the two.

Modifying the motorised pot

The next step is to remove the resistive element and the end stops inside the motorised pot. That's done by first bending out the metal tabs that hold the housing together. Once the element has been removed, the housing can be reassembled.

As shown in the photos, the speed control knob on our projector has in-

The shutter blades in the projector rotate, increasing the apparent frame rate and blocking the light through the lens as each film frame is progressed.

This close-up view shows the photo-interuptor. It must be accurately positioned, so that the shutter blades pass through its slotted opening.

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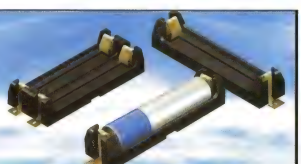

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Avoiding Flicker: Why Film Frame & Video Field Lock is Necessary

A PROJECTED film image is presented as a series of still images (or frames) on the screen. These individual frames are interrupted by blanked-out intervals, where light from the projector lamp is blocked from passing through the film and the lens.

The blanking intervals hide the progression of the film from one frame to the next. This is necessary because during projection, each frame is held stationary for a short period and then progressed to the next frame.

Additional blanked-out intervals are included to increase the effective projection rate. This results in the perception that the images are continuous due to persistence of vision of the eye. Each film blanking period is about 10% of the frame period and together they account for 30% of the overall frame period.

When the projected film image is copied using a video camera, the camera effectively takes photos of the image as a series of still fields at a 50Hz rate. This gives a video frame rate of 25Hz, ie, there are two fields to a frame.

Therefore, if the film frame rate is set at $16^2/_3$ fps, each 25Hz video frame will contain two thirds of a film frame. This in turn means that each second and third video frame will show a different portion of the film frame (or frames).

This cycle repeats every three video frames or after exactly two film frames. As a result, the film frame rate and video frame (and field) rates can be considered to be in lock.

Fig.3 depicts the film frames and video frames side-by-side, to illustrate how the video camera records the film. The film blanking periods and the video vertical blanking intervals are both shown to scale. During film blanking, a black screen is presented to the video camera. Conversely, when there is no film blanking, the camera "sees" the projected image.

Each video frame comprises two separate interlaced fields with a blanking interval between them. That is why a blanking period is shown at the beginning and in the middle of the video frame. No film image is recorded during the video vertical blanking periods.

Fig.3(a). shows two separate film frames (Film Frame 1 and Film Frame 2) against three video frames (Video Frame 1, Video Frame 2 and Video Frame 3). This is when the two are in lock. As can be seen, when the film frames and video fields are in lock, the end of Video Frame 3 lines up with the end of the Film Frame 2. Successive film frames will therefore remain synchronised with successive video fields.

Note that this video recording technique assumes that the differences between Film Frame 1 and Film Frame 2 are minimal, otherwise Video Frame 2 will be blurred.

Fig.3(a) shows Video Frame 1 starting at the same time as Film Frame 1. This ensures that each video frame occurs within a full film exposure period. In other words, video field blanking occurs only during the film frame blanking periods.

Fig.3(b) shows what happens to the synchronisation if Video Frame 1 starts after Film Frame 1 begins. In this case, video field vertical blanking occurs within the film frame exposure period. This results in a slightly reduced average light level exposure for the video picture.

In practice, this means that each video frame in Fig.3(b) will operate for 62% of the film frame period compared to 70% for Fig.3(a). However, provided that the film and video remain in lock, there will no variations in this average level over time.

These 70% and 62% figures represent the highest and lowest exposure periods that can be obtained when randomly starting the projector and

This photo shows how the projector and video camera are set up. The film is projected onto a small screen about 250mm away, while the video camera is positioned alongside the projector to record the images. The projector and the camcorder should each be angled so that they cancel out trapezoidal distortion.

dentations around the rim and these match the flutes on the motorised pot shaft. The motor/gearbox assembly are mounted on a plastic case using aluminium brackets and the case is then fastened to the side of the projector so that the shaft mates with the speed control knob.

If you have a motorised pot with a smooth (ie, non-fluted) shaft, try fitting it with a rubber sheath. This should then provide sufficient friction to drive the projector's speed control knob. A suitable rubber sheath can be obtained from the cable grip section inside a 3-6mm diameter IP68 cable gland.

Alternatively, try fitting some rubber tubing (preferably ribbed) over the pot shaft.

Wiring it up

The photo-interrupter is mounted inside the projector and is positioned so that the shutter vanes pass through its slot. It's then connected to the PCB via twin-core shielded cable. Note that both the cathode (K) and emitter (E) leads of the photo-interrupter are connected to the shield wire – see Fig.2.

The pot motor can be connected using medium-duty hook-up wire. You will have to experiment with the

the camera. This random starting nearly always means that the video fields and film frames are not synchronised to start precisely together. Doing that would be difficult with a mechanically-operated projector and is in any case unnecessary because the exposure periods do not differ much between the two extremes.

Note that when the film and video are in lock, each video frame has the same duration of exposed film and the same duration of blanking – see Fig.3(a).

If the film frame rate changes slightly so that it is no longer locked against the video field rate, then each video frame will begin to receive varying amounts of film frame (ie, the exposure alters). The video frame can now include the film's own vertical blanking period as shown in Fig.3(b), while at other times the blanking will not affect the exposure level as in Fig.3(a).

This exposure level variation becomes worse as the film frame drifts further from video field lock. Fig.3(c) shows what happens with a film frame rate of 14.5 fps, while Fig.3(d) shows what happens at 18.5 fps

For Fig.3(c), Video Frame 1 is fully exposed to Film Frame 1 and the video field blanking coincides with the film blanking. There is also only one film frame blanking period during this video frame.

By contrast, Video Frame 2 has one of its own vertical blanking periods occurring within the film exposure period plus two film frame blanking periods. By the time Video Frame 4 occurs, just when the sequence should repeat, there are two video blanking periods within the film frame exposure period plus two film blanking periods as well.

As a result, the video frames are no longer matched as they are in Fig.3(a) and Fig.3(b). A similar effect occurs in Fig.3(d) where the projector frame rate is too fast.

In summary, if the video frame and film frame rates are out of sync, then the amount of the film frame captured in each successive video frame varies continuously. In addition, there will be variations in the locations of the film blanking periods and these can be captured in the video fields. This will cause variations in the average brightness of successive video fields and cause a very noticeable flicker.

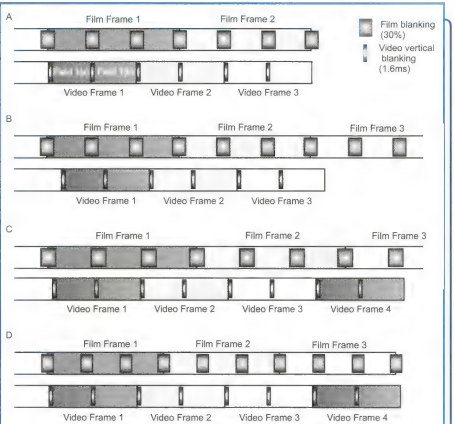
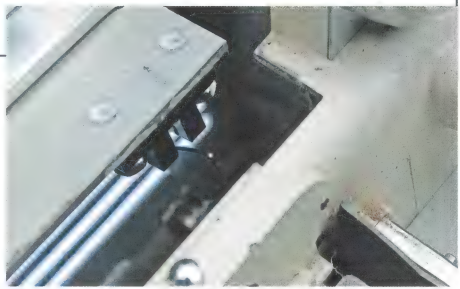


Fig.3: the effect of different film and video frame rates. In Fig.3(a) and Fig.3(b) they are in lock. Fig.3(c) shows what happens when the film frame rate is too slow while Fig.3(d) shows what happens when it is too fast.

polarity until it operates correctly. If the polarity is incorrect, the motor will run continuously and set the projector to either its fastest or slowest speed. At that point, the clutch will slip but the pot motor will continue running.

Conversely, when the polarity is correct, the motor will run to maintain the projector's speed so that it remains in lock. In practice, the motor will be continuously moving back and forth as it endeavours to maintain a constant speed from an imprecise projector mechanism.

That's it – you are now ready to transfer your films to DVDs. SC



This photo-interrupter must be positioned to align with the shutter blades when the case is closed (ie, the shutter blades must pass through its slots).

Agilent Infinii

MSO-X 2024A 4-Channel Mixed Signal Oscilloscope

The new Agilent InfiniiVision DSO/MSO 2000X and 3000X series oscilloscopes will certainly stir up the scope market. They combine high performance and a wide screen format with ease of use – something that is not always a feature of today's digital scopes.

Review by Nicholas Vinen

The great thing about these new models is that they fill the gap between low-end, entry-level digital oscilloscopes and scopes with much higher performance, such as the Agilent 7000 series which have more daunting price tags.

There are 26 new Agilent InfiniiVision models ranging in price from about $1328 plus GST to over $12,000. The particular model we tested is somewhere in the middle.

And like high performance cars there are lots of options such as serial decoding modules (for the mixed signal oscilloscopes), a built-in signal generator, VGA and LAN connectivity, GPIB (General Purpose Interface Bus) and more.

First impressions

Turning now to the 200MHz MSO-X 2024A we tested, the immediately outstanding features are the large screen, a 21cm 800 x 480 LCD panel and the fast waveform update rate (50,000 acquisitions per second).

Not only is the screen large and crisp but it is immediately obvious that the analog front-end is well-designed. The waveforms look clean, even if you set it to maximum sensitivity (which with the provided 10:1 probes, is 20mV/division). At that level you can see a little noise from the acquisition circuitry but it is kept well under control.

This isn't to say that the actual noise being measured has gone away – you can still see it but it is shown as a smooth band around the centre of the trace, thanks to the many sampled waveforms which are overlaid due to the rapid capture rate. The higher screen resolution contributes to the crispness of the displayed waveforms.

If signal noise is an issue, one of the excellent features of the InfiniiVision series (which we make use of regularly on our DSO7034A) is the "high resolution" acquisition mode. This uses oversampling to provide noise reduction similar to averaging mode but without introducing any delays or removing much high frequency information (aside from the noise, obviously). Waveform averaging is also supported, as is peak-detection mode.

The 2000X series oscilloscopes have a high sampling rate: 2GS/s (interleaved mode) or 1GS/s (non-interleaved). The advantage of non-interleaved mode is that each channel is sampled at exactly the same time but then the sampling rate is halved. The waveform memory is quite large at 100,000 points. The 3000X series has an even more impressive 2,000,000 points memory (with an option to double it).

What does the high acquisition rate mean for you, the user? You obviously can't see 50,000 waveforms per second. Well it turns out that this is actually a very useful feature because the scope averages many sampled waveforms and uses the result to vary the intensity of each pixel. This is similar to what an analog scope with phosphor decay does.

In essence, if the waveform is not perfectly consistent, you can see the spread of voltage levels since some areas will be brighter than others. This makes it easier to see "glitches" (oc-

casional deviations from the expected pattern) as well as giving you a better impression of just how much noise and jitter there is in the signal.

It's not just a matter of trying to make the number more impressive – this is a true improvement in usability that was previously limited to very expensive DPOs (Digital Phosphor Oscilloscopes).

User interface

A major benefit of the new models is the uncluttered control layout. Because they are taller than the Agilent 1000 series, they can fit a lot more controls (including the four side-by-side vertical adjustment knob sets) without being much wider.

There are a lot of buttons on the front panel but they are clearly labelled and grouped logically. Overall, this makes the interface easy to use.

Here are some of the benefits from the extra buttons. The "Force Trigger" is useful when the acquisition is in "Normal" mode (as opposed to "Auto"). In normal mode, the display does not update unless the trigger condition is met. This can be useful for catching occasional signals but it's annoying if isn't triggering since you can't see why. Now you can easily force it to trigger and then adjust the trigger conditions as necessary.

The "navigate" button cluster includes a left and right arrow with a "stop" button in the middle. These allow a constant-speed pan across the timebase, akin to turning the time offset knob at a particular rate.

There are several speed settings which are stepped through with multiple presses of the arrow buttons. This is more convenient than using the knob if you have zoomed in to view the details of a complex waveform.

There is also a "Quick Action" button; the action is set by the user. We set it so that a press will save the screen to a PNG file on the USB flash drive. It can also be configured to show all possible measurement values ("snapshot measurement" mode), print the screen, recall a saved configuration, freeze the display, change the trigger mode or clear the display (when persistence is enabled).

The "Zoom" mode on this unit works quite well and there is a dedicated button at the top, which looks like a magnifying glass, to toggle it on and off. In this mode, the horizontal adjustment knob changes the zoom factor while the delay knob, as well as the navigate buttons, allow for the expanded portion of the waveform to be moved (see Fig.2).

All the knobs also have a pushbutton action and in most cases this either resets the value to zero or else toggles the vernier (fine adjustment) mode on and off for that control.

Nice touches

Agilent have put quite a lot of thought into the usability of these models and they have a number of small details which improve the user experience.

For example, you can attach a text label to each channel which is then shown in various places on the display (eg, when selecting a channel to

Here's a view of the back of the scope. Of most interest is the right side, revealing two USB ports (device and host), trigger out and trigger in sockets and below them the optional LAN/VGA port, which we'll look at more closely shortly.

measure). You can select from a list of built-in labels or enter your own. This makes it much easier to remember which waveforms correspond to which points in your circuit (or to indicate it on printouts or screen grabs).

You can position a small "time reference" triangle which is relative to the trigger point and then use this to calculate delays and such. It's like a horizontal cursor but less obtrusive. There is also a "probe skew" setting which allows you to adjust for cable delays in the probes.

The optional "Mask" mode can be used to check whether a signal is within a particular range. The mask can either be loaded from a PC (say, from a USB drive) or it can be derived from a captured waveform in combination with a tolerance setting (see Fig.3).

A waveform can also be stored and used as a reference. In this case it is displayed as an orange trace, for comparison to live data. As with other traces, it can be changed in scale or offset. It can also be moved along the timebase ("skewed").

In zoomed mode, measurements can be taken from the main or zoomed window (or the selection left on "auto").

You can also make measurements from digital inputs and computed ("Math") traces, although with some exceptions. There is a "snapshot all" option which shows a large number of instantaneous measurements for the selected channel in the middle of the screen (see Fig.4).

The measurement selection menu is particularly good, as not only is the selection of measurements comprehensive (eg, you can even select how many cycles RMS values are computed over), each selection is shown adjacent to a small picture indicating what the measurement represents. Measurements are also grouped under sub-headings according to type. So selecting the appropriate measurement to display is easy (see Fig.5).

If you turn the soft-button menu (at the bottom of the screen) off, using the Back button, in its place is displayed the coupling mode for each channel, the offset voltage setting for that channel and the probe attenuation ratio. To the right of the channel information is the current time and date. No screen space is left unused.

There is also a "file explorer" feature which allows you to view and navigate the contents of the USB flash drive plugged into the host port as well as view files stored in the scope's internal memory.

In addition to the normal and XY display modes (where channels 1 and 2 are plotted relative to each other as a Lissajous figure), there is also a "roll" mode where the screen scrolls from right to left and new data is constantly added to the right-hand side.

This can be useful for viewing slowly changing voltages but is limited to relatively slow time bases (it would be impractical otherwise).

Triggering

These new Agilent scopes have the basic triggering options – edge, pulse width and video – as well as pattern triggering, which is mostly useful for use with the logic analyser. Unfortu-

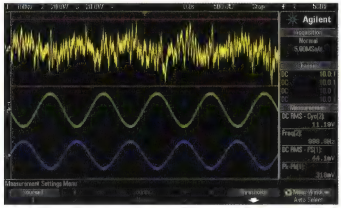


Fig.1: using the test unit to make an amplifier distortion measurement, with the distortion residual at the top and the test waveforms underneath. Note the measurements at the right side of the screen with the orange dashed cursor indicating the peak-to-peak measurement points.

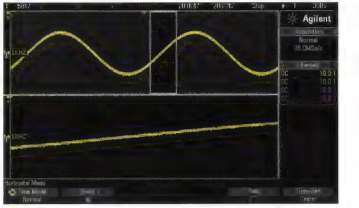
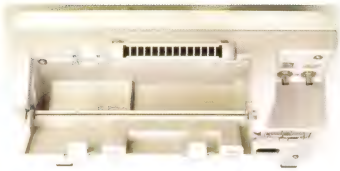


Fig.2: the zoom mode is easy to operate, especially with the navigation buttons which perform constant-speed panning across the captured waveform. The large memory and low noise allow small details to be seen in the zoomed view. The scope updates at the full rate when in zoom mode.

Along with the four 10:1 probes (one for each channel) comes a generous assortment of bits: the usual hook probe adaptor, earth alligator and spring clips, colour coding bands, spare points, RF connector adaptor and IC pin probes.



And there's even somewhere to store them: there is a flip-down lid on the rear panel which reveals this handy storage compartment. Or it could be used to store the IEC mains lead, which is supplied with the scope.

nately, there is no alternate/sequential triggering to allow each channel to operate with its own timebase or any advanced, configurable analog trigger conditions.

However there are some handy options such as adjustable trigger coupling (DC, AC and high-pass filtered), noise rejection, a low-pass trigger filter ("HF reject") and a configurable hold-off setting, adjustable from 40ns to 10s, which prevents immediate re-triggering.

The video triggering mode has all the usual bells and whistles to select particular lines to trigger on, alternate fields etc. We have to wonder though, how many people are still using oscilloscopes to work on analog video equipment. Not many, we would guess.

"Math" modes

These new Agilent scopes have the usual add, subtract multiply and FFT modes (see Fig.6). But one very nice aspect is that there are dedicated scale and offset knobs which allow you to easily move and scale these "virtual" channels, just like you can with the regular channels. Those knobs are used for the same purpose with the logic analyser (in Serial or Digital mode) and the reference waveform.

With other oscilloscopes (including some high-end models!) doing this is quite awkward as it involves pressing the soft buttons (below the screen) and twiddling the general adjustment knob. In the past this has been very frustrating but with this model, it is easy.

Also, since you can set the units for each channel to Volts or Amps, if you use the "Math" feature to multiply two waveforms, it displays the correct units (V^2, A^2 or W, depending upon the units of the source channels). This is a nice touch.

Ports and connectors

The front panel sports the typical line-up of connectors: a BNC input connector for each channel, a probe calibration square wave output, a BNC output connector for the signal generator module (which only works if you have that option), the logic analyser port and a USB host port for flash drives and such.

At the rear are the BNC sockets for the trigger input and output, mains connector and expansion port. There is an additional USB host as well as a USB device port on the rear. This allows for connection to a printer as well as a PC to control the oscilloscope functions.

Accessories

Standard 1.2m-long, 10:1 probes are provided for each channel. Each probe comes with a generous assortment of bits: the usual hook probe adaptor, earth alligator and spring clips, colour coding bands, spare points, RF connector adaptor and IC pin probes.

Another nice feature is the clip-on

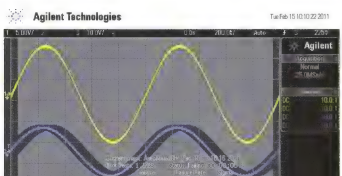


Fig.3: the mask testing mode. The mask was made from channel one and is being applied to the signal on channel three. The number of failures (ie, excursions outside the mask) is displayed, which could be very handy for use in production testing.

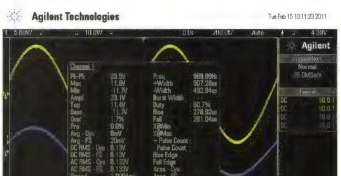


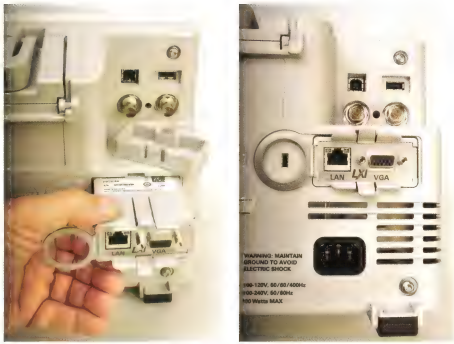
Fig.4: the "snapshot measurement" mode which shows all the vital parameters in once place, for a single channel. This avoids fiddling with the measurement menu when you want to check a single figure. The problem is that this obscures the displayed waveforms themselves.

moulded plastic cover which protects the scope while you are carrying it but it also keeps dust off the knobs and screen when not in use.

Also provided are a mains power cord, user manual (on a flash drive) and calibration certificate. For the mixed signal models, the appropriate logic analyser dongle and test clips are provided. The user manual is very well-written and is quite detailed; so many scope manuals are not.

Another excellent design feature is the compartment located at the top of the unit, to the rear. With some careful arrangement, four probes with hook adaptors and earth leads can be stored inside. This is great for transporting the scope and should also reduce workbench clutter when the oscilloscope is not in use.

The provided probes have autosensing support but the 2000X series oscilloscopes do not. Since they have a fixed 10:1 attenuation and this is the default setting, it isn't really a problem. If you use different probes then it is necessary to manually select the attenuation factor for correct voltage scaling.



Here's how that optional LAN/VGA module connects into the scope – the snap-out cover is removed and the module simply slides into place. The ring and socket on the left side is for a Kensington lock which prevents both the scope and module from being stolen.

Logic analyser

The logic analyser on the mixed signal models has eight channels on the 2000X series and 16 channels on the 3000X series models. They have all the typical features and voltage threshold levels can be set anywhere between -8V and +8V. The channels can be displayed and used for triggering, including a "pattern" trigger which waits for a certain state to appear on some or all of the lines.

The digital inputs can be grouped arbitrarily into one or two buses, with the content of each bus displayed as binary or hexadecimal values. You can then set the pattern trigger to occur when a particular value appears on a particular bus. The bus can then be displayed in addition to the individual digital channels that it comprises (see Fig.7).

Optional features

In addition to the mixed signal models, quite a few options are available. This includes an inbuilt signal generator, a GPIB module, an ethernet/VGA module and serial decoding modules for the 3000X series MSOs (I^2C/SPI, RS323/422/485/UART and CAN/LIN).

Our review model was provided with the signal generator and ethernet/VGA modules. The signal generator option is particularly handy as it gives you all the usual features without the need to have a separate unit on your workbench. All related functions are accessed via a "WaveGen" button which lights up blue when the generator is active.

The waveform choices are sine,

Fig.5: the new measurement selection window, showing how measurements are grouped and the diagrams which indicate how they work alongside. This prevents confusion over what you are actually measuring.

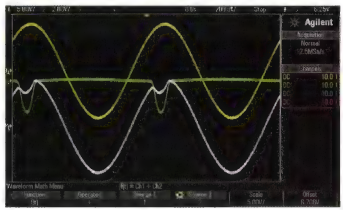


Fig.6: in this screen shot we are using the "math" menu to generate a third trace which is the sum of two captured waveforms. The multiply mode is especially useful for power measurement.

square, ramp (triangle), pulse, DC and white noise. In all cases the DC level (offset) is adjustable and except for DC, the amplitude can be set, either as a peak-to-peak voltage or by defining the minimum and maximum voltage levels. Frequency/period can be set for all modes except DC and noise. There are other parameters too like square wave duty cycle, ramp symmetry and pulse width.

The waveform generator can be synchronised with the oscilloscope trigger system or it can produce a separate sync pulse. It can also be synchronised with the mask system.

The maximum generator frequencies are 20MHz for sinewaves, 10MHz for square and pulse (which are no longer quite square at maximum frequency) and 100kHz for ramp. The amplitude is generally adjustable from 20mV to 5V peak-to-peak. The 1kHz sinewave output has around 0.2% harmonic distortion which is not unreasonable given its large frequency range.

The combined Ethernet/VGA module slides into the rear of the unit and clips in place, providing the two additional ports without taking up extra space.

The VGA port duplicates the LCD content on an external display and this could be useful for those with vision problems or in training/educational situations as the output can be connected to a projector.

The Ethernet port allows for remote control and for data to be loaded onto and off the device. But USB connectivity is so convenient, this does not seem especially useful. It could be handy in automated test and production environments or for long-term logging and testing. Interestingly, with the LAN module, the oscilloscope can provide a web interface.

Another option provides "segmented memory", which allows multiple waveforms to be captured separately, in sequence. You can then switch between them for display and analysis.

Possibilities for improvement

With this new range of oscilloscopes, you get a very capable unit for a reasonable price. But there are a few areas in which we feel software changes could make it even better. For example, while the screen is large, you cannot actually use its full width to display waveforms. Instead, to the right of the screen is permanently displayed information such as the acquisition mode and rate, the probe division ratios and the quick measurements. While this is all useful, it isn't always vital and we would like to use the full width of the screen just for the waveforms. No such option is in evidence.

And with such a large screen it should be possible to show more than four measurements. Again, this may mean hiding the acquisition and probe data but we would happily do so to be able to show eight or ten measurements at once, without obscuring the waveform area.

The 3000X series

For more money you can get a scope in the 3000X series, which is physically quite similar but has some important improvements, some of which have already been mentioned: 16 digital channels, serial decoding options and the substantially larger sample memory (2Mpoints).

In addition, there is more bandwidth (up to 500MHz), a doubled sampling rate of 2/4 gigasamples per second and the waveform update rate sky-rockets to one million per second. The 3000X series also has support for active probes, probe auto-sensing capability and waveform search and navigation.

Educational features

These scopes have a number of features tailored for the educational market, especially electrical and electronic engineering labs in universities and technical schools. We already mentioned the VGA output option but there is also a "training mode" option (called the Education Oscilloscope Training Kit).

With this, it is possible to configure the scope's signal generator to produce a series of waveforms which present students with particular challenges. These signals are available at the "Demo 1" and "Demo 2" terminals at the front of the scope (one of which doubles as the calibration signal source) and the separate waveform generator option is not necessary to use this feature.

Note that some of the training signals use two channels, hence the two outputs. For example, the "phase shifted sine" option presents two sine waves with a phase difference between them at each of the two training (demo) outputs.

Some of the other signals include occasional errors, either "glitches" (occasional deviations in pulse width

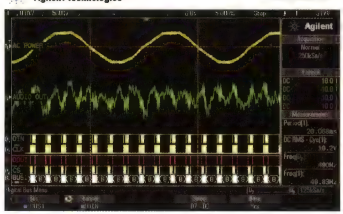


Fig.7: a demonstration of the Mixed Signal Oscilloscope mode with bus support. This shows the usefulness of channel labelling. With the serial decoding options, serial buses can also be displayed.

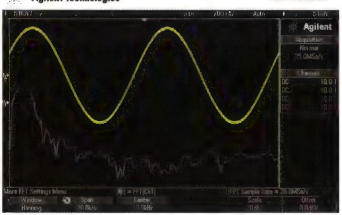


Fig.8: here the "math" FFT mode has been applied to a 1kHz sinewave. Its resolution is limited at low frequencies so this mode is more useful for RF signals than audio signals. The FFT configuration menu can be seen at the bottom of the screen.

or rise/fall-time) or "runts" (pulses with lower than normal peak voltage). Students can use this mode to learn how to adjust the scope in order to observe these occasional phenomena. See Fig.9 for an idea of the training signals available.

As mentioned earlier, one of the major advantages of having a scope with a fast update rate is the ability to catch glitches more easily, so the training mode also gives a good demonstration of the capabilities of this series.

Agilent recognise the educational potential of these new models and are offering literature for teachers and students, to guide them through this process. These documents are downloadable, free of charge. In educational situations, it is also possible to disable the "Auto Set" button so that students learning how to use the various systems can't take a shortcut.

Trio Smartcal are currently offering a special deal for educational institutions when purchasing 2000X or 3000X-series oscilloscopes. The signal generator and training mode options will be included at no additional cost, in addition to their normal 15% discount for educational institutions. They plan to keep this deal running for as long as possible.

Additional benefits

Past contributor David L. Jones made an interesting point at the launch event: the training mode is useful for experienced scope users too. If you are trying to capture a glitch which occurs very infrequently, you want to be sure that you have set the scope's trigger system up properly. If it is not set correctly, you could wait all day and then miss that one glitch.

Using the built-in glitch generator in the training module, you can check that the trigger is activating properly, then simply swap the probe(s) over to the prototype. Users who are debugging high speed digital logic circuits (where occasional glitches can be an issue) may wish to purchase the training module for this reason.

Upgrade path

Earlier, we mentioned that there are several options available and we are glad to say that these can be purchased at any time. But have not yet revealed just how upgradeable these scopes are.

While there are 26 new models, in reality you only need to decide between four main options. These are the 2- and 4-channel 2000X-series models and the 2- and 4-channel 3000X-series models.

You can then purchase and apply upgrades at any time, even going to a wider bandwidth after having purchased the scope! Other upgrade possibilities are more memory, adding the signal generator or logic analyser (turning a DSO into an MSO), adding the segmented memory option and so on. This has not been possible with any previous scopes (officially, anyway).

If you know exactly which features you want, you can purchase the particular model and options up-front but even then, you still have the possibility to upgrade it further. Almost all the upgrades are performed by entering a code so there is no need to send the unit out. The exception is when a 3000 X-series scope is upgraded to from 100-200MHz to 350-500MHz bandwidth.

One interesting option we have not mentioned yet, which is only available with the 3000X-series, is a "power measurement and analysis application". This could be quite useful for those designing or fixing power supplies.

Conclusion

These are cheaper scopes than these available. There are also more capable scopes available. But there really isn't anything right now that offers so much performance for so little money.

These two new Agilent scope series are a major leap forward in terms of the performance and ease-of-use, available at a very reasonable starting price. The large range of models and options allows you to customise the oscilloscope to your needs and even the most basic models have an excellent set of features.

The model we have reviewed, the MSO-X 2024A, costs $3580 plus GST. The signal generator option is $539 plus GST (771 for the 3000X); training mode is $539 plus GST and the LAN/VGA module is $426 plus GST.

If this seems expensive, do not fret because the 2-channel, 70MHz DSO-X 2002A is $1328 plus GST and the 4-channel, 200MHz DSO-X 2024A (without logic analyser) is $2824 plus GST.

At the other end of the scale, the deluxe MSO-X 3054A with 4 channels, 500MHz bandwidth and 16 channel logic analyser is $12,514 plus GST.

There are 26 models in all, not including the options. For further information on the models, or to make a purchase, contact Trio Smartcal. Call 1300 853 407 or visit www.triosmartcal.com.au SC

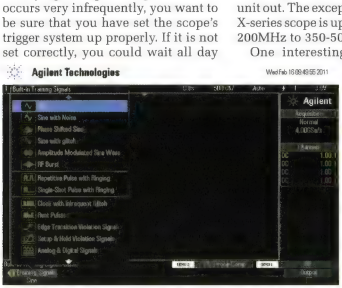


Fig.9: the menu (accessible via the Help button) which allows the user to select from the available training signals, if that option is installed. This list is incomplete, as you can see from the scroll arrow at the bottom of the menu.

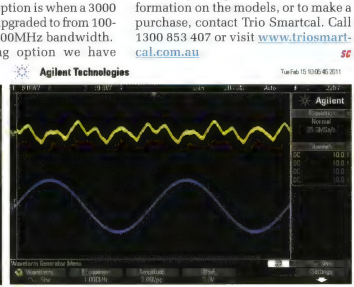
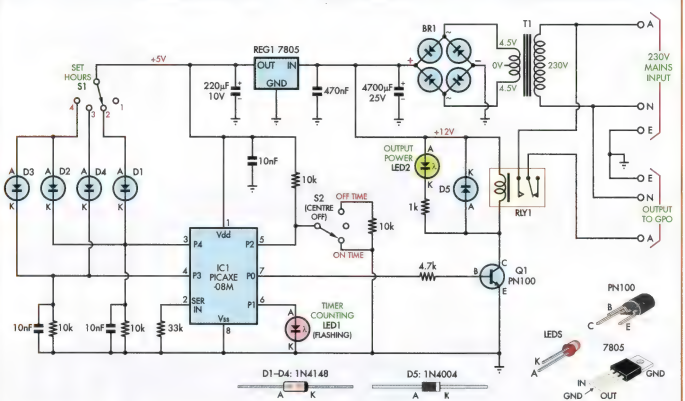


Fig.10: the blue trace is the output from the generator which has been connected back to channel 3 and the yellow trace shows the distortion residuals as measured by an Audio Precision System One analyser, at 0.15%.

CIRCUIT NOTEBOOK

Interesting circuit ideas which we have checked but not built and tested. Contributions from readers are welcome and will be paid for at standard rates.



Mains timer for battery chargers

We all have mains rechargeable tools and devices but many don't have smart chargers. It is too easy to put a drill battery on charge only to return, sometimes days later, to find a hot and probably overcharged battery. Mechanical timers (with the little plastic keys) can be used but they are fiddly and inconvenient.

This simple timer using a PICAXE08M micro is the answer. It switches power to a GPO (mains power socket), either during or at the end of a timing cycle, and has four timing periods which can be easily selected. The program allows a reset of the timer with any change in position of switch S1 or S2 during the timing period and S2 will reset the PICAXE-08M after the timing period is complete.

Diodes D1-D4 set up the logic via S1 to inputs P3 and P4 for the four timing periods of 1, 2, 3 or 4 hours duration. S2 is a SPDT centre-off switch. According to the program, in the centre-off position, ADC input P2 is at 5V which resets the timer.

In the "Off Time" position, P2 will be 2.5V, the 5V being divided by the two 10kΩ resistors. In this setting, relay RLY1 will not be turned on until the timing period has ended. This function could be used to delay turning on a slow cooker.

Conversely, with S2 in the "On Time" position, pin 2 will be 0V and relay RLY1 will operate during the timing period. This supplies 230V to the charger and then switches it off.

LED1 is a flashing type with low current drain, so no current-limiting resistor is required. LED2, across the relay coil, is a GPO mains on indicator.

You can change any of the four timing periods to a value between one second and over 18 hours by first calculating the number of seconds required. This then becomes the new value of Word1 (W1) in the program for the desired switch position. The set time is approximate and varies by a few seconds due to the internal clock speed and the time the PICAXE takes to execute the program. However, this is insignificant for the purpose of this project.

The software, *GPOTimerACD.bas*, can be downloaded from the SILICON CHIP website.

Paul Walsh,
Montmorency, Vic. ($80)

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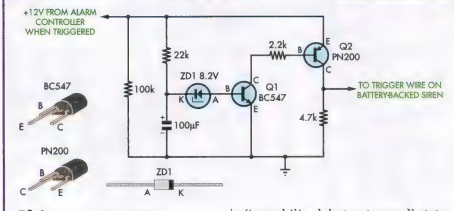


Chirp suppressor for a car alarm

This circuit was produced to suppress the chirps from a Mongoose car alarm.

Most car alarms these days allow you to disable the arm and disarm chirps in software. However, this particular Mongoose alarm won't let you disable the auto-immobiliser chirp which sounds 30 seconds after you have turned the key off. Nor can you disable the "chirp chirp chirp chirp . . ." when you accidentally turn the key on with the alarm in this (immobilised, but not armed) state.

The circuit connects between the alarm controller's "siren trigger" output wire and the input to the battery-backed siren device. In essence, it blocks any signal that is shorter than about one second. This has the effect of blocking all chirps (arm/disarm/auto-immobilise/key-on-when-immobilised) and it only adds a 1-second delay to the siren sounding when a real break-in event occurs.

The circuit also has to cater to the siren's "anti-tamper" detection facility which can detect when the trigger wire is cut. This is achieved with a 4.7kΩ resistor between the trigger wire and earth when the siren is not sounding. If the circuit is housed in a hidden location (ie, up in the dash near the alarm controller) then the anti-tamper detection continues to work as originally designed (ie, if the trigger wire between the circuit and the battery-backed siren is cut, the siren will sound).

The circuit works as follows. When no 12V signal is received from the alarm controller, the battery-backed siren is connected to 0V via the 4.7kΩ resistor at the collector of PNP transistor Q2 and therefore the siren does not sound.

However, when a 12V signal is received from the alarm controller, the 100µF capacitor charges via the 22kΩ resistor until the voltage across zener diode ZD1 reaches about 8V at which time base current flows into the base of NPN transistor Q1. This process takes about two seconds.

When Q1 conducts it turns on Q2 and this applies 12V to the trigger wire for the siren, thereby causing it to sound.

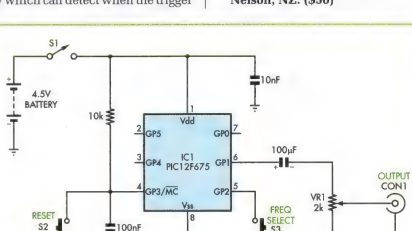
Peter Mundy,
Nelson, NZ. ($50)

PIC-based square-wave generator

While a 555 timer or Schmitt-trigger oscillator can be used to generate variable frequency square waves, this circuit has better frequency stability and repeatability. It can be handy for checking amplifier operation, for measuring amplifier transient response and stability and for signal injection when servicing AM radios.

The PIC12F675 microcontroller (IC1) can be powered from three 1.5V button cells (AA and AAA cells also work). The square wave output appears at pin 6 (GP1) and is AC-coupled using a 100µF capacitor and 2kΩ pull-down resistor, so that it is symmetrical about ground. Potentiometer VR1 (2kΩ) allows the output level to be adjusted and keeps the output impedance at 500Ω or less, by dint of its voltage divider action.

Switch S1 turns on the device



while tactile pushbuttons S2 and S3 allow the output frequency to be set. By default, the available output frequencies are 200Hz, 1kHz, 2kHz and 10kHz. Pressing S2 sets the frequency to 200Hz while pressing S3 advances to the next frequency. After 10kHz it goes back to 200Hz.

The timebase for all frequencies is derived from IC1's internal 4MHz RC oscillator which is factory calibrated to within 2% over a temperature of 0-85°C. The available frequencies can be changed or augmented by modifying the source code.

Both the source code and hex file can be downloaded from the SILICON CHIP website (PIC_square_wave.zip).

Alex Sum,
Eastwood, NSW. ($55)

H-bridge circuits for robotics

While the dual-motor control circuit for robotics applications (SILICON CHIP, December 2010, p58) uses low-cost parts, it does use rather a lot of them; 36 to be precise. If you don't have those parts in your collection, it could be an expensive exercise.

As an alternative, typical H-bridge ICs contain all the drive components and in some cases include protection diodes as well. After reviewing over 25 H-bridge ICs from various manufactures – Texas Instruments (TI), Rohm, ST Microelectronics (ST), National Semiconductor, Freescale (FS), Intersil (IN), Harris Semiconductor (HS) and International Rectifier (IR), I weaned them down to those listed in the accompanying table. Two circuits were then built which featured readily available ICs from **au.element14.com**

Circuit 1 uses the Texas Instruments SN754410 or TI/ST L293/L293D Dual H-Bridge rated for 1A from 4.5V to 36V DC in a PDIP package. Circuit 2 uses an ST Microelectronics L298 dual H-bridge rated at 4A from 5V to 46V DC in a Multiwatt 15 package.

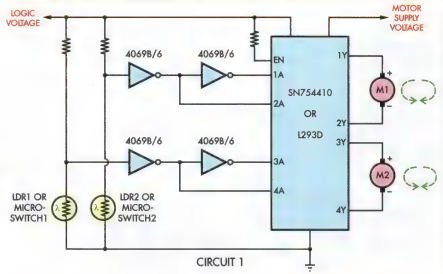
As with the design referred to above, the suggested ICs will drive two motors in the forward or reverse direction and if the enable input is used, stop the motor. The ICs have internal output transistor protection diodes, thus reducing the component count even further.

The detection circuit remains the same: two LDRs (or microswitches) provide the direction of travel information. If the path is clear in front of the LDR then it will have a low resistance (logic '0'). Conversely, if the path is blocked it will have a high resistance (logic '1'). Logic '0' = Forward; Logic '1' = Reverse.

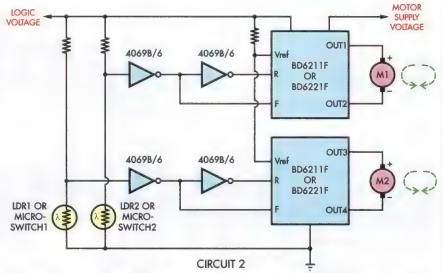
A 4069 CMOS hex inverter has been added to provide a positive switching point and an inverse direction signal for the motor control IC. Allowing the motor to go into reverse if an obstacle is detected results in the robot backing away to clear the obstacle. As soon as the sensor is cleared, the motor will switch back to the forward direction.

Should additional direction logic control be required a small micro could be substituted in place of the hex inverter to allow more complicated direction logic to be provided.

Mike Abrams,
Ipswich, Qld. ($80)



CIRCUIT 1



CIRCUIT 2

Manufacturer	Part #	Package	H Type	Voltage	Current	Cost
TI TI/ST	SN754410 L293 L293D	PDIP	Dual	4.5-36	1.0	$5.00
ROHM	BD6210	SOIC8	Single	7	0.5	$3.40
ROHM	BD6211	SOIC8	Single	7	1.0	$3.45
ROHM	BD6212	SOIC8	Single	7	2.0	$5.15
ROHM	BD6220	SOIC8	Single	18	0.5	$4.25
ROHM	BD6221	SOIC8	Single	18	1.0	$3.45
ROHM	BD6222	SOIC8	Single	18	2.0	$9.40
ST	L298	Multiwatt 15	Dual	5-46	4.0	$9.50
NS	LMD18201	Multiwatt 15	Single	5-55	3.0	$10.50
ST	L6225	PowerDIP20	Dual	8-52	1.4	$11.55
FS	17510	TSSOP24	Single	4-15	1.2	-
ST	VN772K	SOIC28	Dual	5.5-36	9.0	-
JRC	NJM2675	PDIP	Single	4-55	1.2	-
HS	HIP4082	PDIP	Driver	5-15	NA	-
IR	AUIRS2003	SOIC8	Driver	10-20	NA	-

Peter Shoote is this month's winner of a Peak Atlas Tex instrument

LED light controller

This circuit controls a number of LED lights powered from a 12V battery. They can be manually switched on and off but if the battery voltage drops below a preset threshold, they go off automatically. It also displays the battery charge state.

It is useful when a vehicle battery is used to power lights (eg, while camping) as it ensures that the vehicle will still start in the morning, even if the lights are left on. Each of the three outputs can power up to about 10W of lights (eg, high-brightness white LEDs).

The upper half of the circuit implements the on/off switch and low battery cut-out. This section is powered from the battery via a 100Ω current-limiting resistor, 15V zener diode ZD1 and a 100µF filter capacitor. This protects the circuitry from battery voltage spikes, eg, when starting the motor.

REG1 is a 2.5V shunt reference and its bias current is set to around 630µA by a 15kΩ resistor. Its output is filtered with a 10µF capacitor and then divided using VR1. VR1's setting determines the battery voltage at which the lights are switched off. The battery voltage is divided down by the 47kΩ and 4.7kΩ resistors, filtered by a 100µF capacitor and fed to pin 3 of comparator IC1a. Its pin 2 is connected to the wiper of VR1.

When the battery voltage is below the preset threshold, the voltage at its non-inverting input (pin 3) goes below the voltage at its inverting input (pin 2) and the open-collector output switches on, pulling pin 1 low. Positive feedback via the 10kΩ resistor provides hysteresis since when the lights switch off, the battery voltage can jump substantially and this might otherwise cause oscillation.

The other half of the dual comparator, IC1b, buffers the output from IC1a and this controls an RS flipflop formed from two NAND gates, IC2c and IC2d. If either input to IC2d (pin 12 or 13) is pulled low, IC2d's output goes high and the latch is reset, switching off Mosfet Q1 by pulling its gate high. This cuts power to the lights.

Pin 12 of IC2d is pulled to ground by IC1b if the battery voltage is too low and therefore the lights remain off until the battery voltage increases. The lights can also be turned off manually, by pushbutton S2, which pulls pin 13 of IC2d to ground. If the lights are off, they can be turned on with pushbutton S1, which pulls pin 13 high.

If the battery voltage is below the threshold, pulling pin 13 of IC2d high would not normally turn the lights on since pin 12 is low. However, pushbutton S1 also increases the voltage at pin 2 of IC1a via a 47kΩ resistor. With S1 pressed, the 100µF capacitor at IC1a's pin 3 input charges to a higher voltage than usual, allowing S1 to override the low battery cut-out if it is held down.

The lower half of the circuit allows the battery charge state to be determined. It is only powered while pushbutton S3 (test) is pressed, enabling the bargraph. In this case, NPN transistor Q2 is turned on and if Q1 is also on, red LED11 flashes.

The bargraph circuit is based on IC3, an LM3914 10-LED driver. It is based on the Vehicle Multi-Voltage Monitor circuit from the May 2006 issue of Silicon Chip.

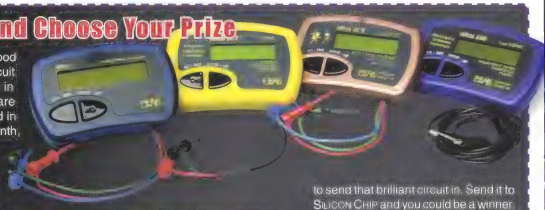
The battery voltage is reduced by a resistive divider consisting of a 1.2MΩ and 100kΩ resistor and then applied to pin 5 of IC3, the signal input. This voltage is compared to the MAX and MIN reference voltages, set by trimpots VR3 and VR4. Depending on the relationship between these three voltages, some or all of the 10 LEDs (LEDs1-10) light.

Trimpot VR2 adjusts the bargraph LED current and thus sets the brightness.

To set up the circuit, calculate the lowest tolerable battery voltage and then divide this by 5.41. Then, adjust VR1 so that its wiper voltage matches your calculation. For example, to switch the lights off once the battery reaches 11V or less, set VR1 so that its wiper is at 2.03V. Instructions for adjusting trimpots VR2-VR4 can be found in the Vehicle Multi-Voltage Monitor article (May 2006).

Peter Shooter,
Fremantle, WA.

Contribute And Choose Your Prize



As you can see, we pay good money for each of the "Circuit Notebook" items published in Silicon Chip. But there are three more reasons to send in your circuit idea. Each month, at the discretion of the editor, the best contribution published will entitle the author to choose a prize: an LCR40 LCR meter, a DCA55 Semiconductor Component Analyser or an ESR60 Equivalent Series Resistance Analyser, with the compliments of Peak Electronic Design Ltd – see www.peakelec.co.uk

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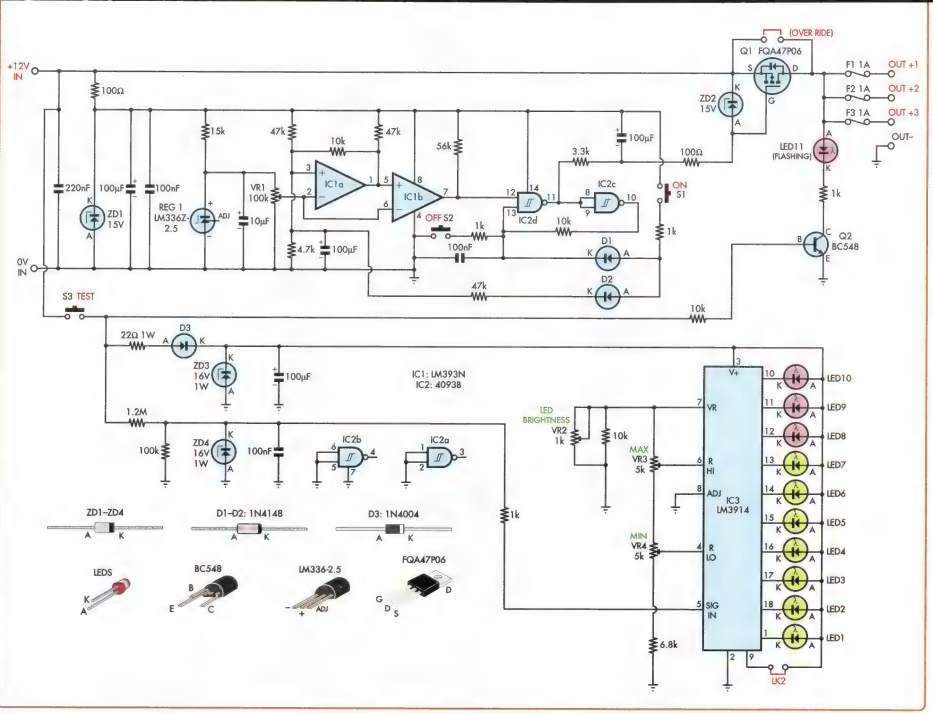
+12V IN
0V IN
100Ω
220nF
100µF
100nF
ZD1 15V
REG 1 LM336Z-2.5
ADJ
1.5k
VR1 100k
10µF
47k
10k
47k
IC1a
IC1b
4.7k
100µF
56k
OFF S2
1k
100nF
S3 TEST
22Ω 1W
D3
ZD3 16V 1W
100µF
1.2M
100k
ZD4 16V 1W
100nF
IC2b
IC2a
IC1: LM393N
IC2: 4093B
3.3k
100µF
IC2c
IC2d
10k
D1
D2
47k
10k
ON S1
100Ω
1k
Q2 BC548
(OVER RIDE)
Q1 FQA47P06
ZD2 15V
LED11 (FLASHING)
F1 1A
F2 1A
F3 1A
OUT+
OUT+1
OUT+2
OUT+3
LED BRIGHTNESS VR2 1k
10k
MAX VR3 5k
MIN VR4 5k
1k
6.8k
IC3 LM3914
V+
VR
R HI
ADJ
R LO
SIG IN
LED10
LED9
LED8
LED7
LED6
LED5
LED4
LED3
LED2
LED1
UK2
ZD1–ZD4
D1–D2: 1N4148
D3: 1N4004
LEDS
BC548
LM336-2.5
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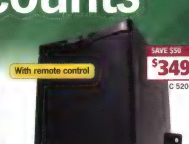

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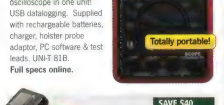

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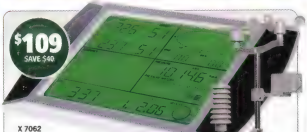

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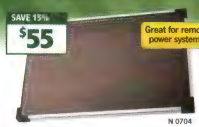

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K 9550

The Maximite BASIC Computer Kit

(SC March '11) Utilising the new Microchip PIC32 processor, this powerful embedded computer can read/save programs on an SD card. A keyboard input & video output is provided, plus 20 digital/analog inputs and outputs. Utilises BASIC programming language allowing a massive scope of applications. • 128K RAM • USB connection • Powerful BASIC interpreter • Requires 9V power supply (M 9237A $17.95) • SD card sold separately (DA0320 4GB $21).

NEW KIT!

K 6021

High Power Ultrasonic Cleaner Kit

(SC August '10) Build this large, heavy duty ultrasonic cleaner and blast away grime from virtually anything, using just water & a little household detergent. Sensor can be dunked into a bucket of water for cleaning large objects. Great for cleaning car parts, bric-a-brac and more!

More Great Kit Designs From Silicon Chip...

SAVE 12%

K 6115

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Measures from -55°C to +125°C & provides a set of NC/NO contacts for activating devices at preset levels. • 0.1°C accuracy • Ideal for air conditioners, cool rooms, cellars etc • Locate sensor up to 300m away • Adjustable temp limits. Requires 12VDC (M 9272A $17.95).

SAVE 40%

K 1010

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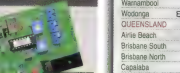
(SC May '04) Powers up two 1W/3W LEDs or a single 5W LED. The switching regulation employed means that it is very efficient and produces very little heat. 12V input makes it perfect for boats, cars & caravans, anywhere low voltage lighting might be required!



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(SC October '08) A handy timer module designed to accept a trigger input from a rising or falling voltage. When triggered the timer can switch devices on for any period between 0.1s and 16.5 minutes.

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K 1687

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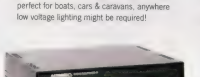

SAVE $50

K 6015

The ultimate model railway controller

Rail Power Controller Kit

(SC Sep-Oct '08) A great value model railway controller offering remote control, pulse power for realistic low speed train movement, speed bargraph & adjustable braking inertia. 15-17V output up to 6A. A 1012 remote to suit $19.95. 240V operation.

SAVE 37%

K 5114

40W Amp Module

Ideal size for building into an active speaker enclosure or PC sound system! **(SC Mar '94)** Super compact design! Delivers 40W RMS into 8Ω. Includes heatsink. Based on the LM3876 IC. Power supply not included. M 5325 transformer to suit $52.50.

Resolves lower values than most LCR meters

K 2533

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(SC May '08) Great for testing capacitors and inductors with unknown values. The perfect addition to the enthusiast or technician's tool box! Requires 9V battery (S 4971 $5.95) Inductance: 10nH-70mH Capacitance: 0.1pF-800nF

SAVE $20

K 4065

Take The Guess Work Out Of Fixing Your Car!

(SC Feb '10). This car interpreter kit connects to your laptop and provides real time readouts from a multitude of engine sensors (in vehicles fitted with OBD II port). Ideal for mechanics & car enthusiasts. May require a RS232 to USB converter, D 2340B $29.95.

Measures to 65,000RPM

K 2510

SAVE $10

LED Strobe & Tachometer Kit

(SC August '08) Allows you to measure the RPM of fans, shafts, propellers or anything that rotates! Readout displays RPM and frequency, 1RPM resolution. Adjustable flash period & divider options. Requires 12VDC power.

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Building The Maximite

Part 2 – by Geoff Graham

LAST MONTH, we introduced our all-new, PIC-32-based microcomputer with its purpose-written MMBASIC language. Now we're getting on to the fun part: building it!

We mentioned at the end of last month's article that a kit would be available from Altronics for the Maximite. That has now been firmed up: a complete kit of parts, complete with a pre-programmed PIC-32 and **already soldered** onto the PCB, should be available this month from Altronics stores, resellers and internet/mail orders for just $79.95 (Cat K-9550). That represents real value for money!

Options

Before you start on construction there are a couple of decisions to make. Firstly, you can set up the video output to be VGA only or composite only or switchable between the two.

The combinations for these options are shown in Table 1. Most constructors will use the VGA output (ie, for a standard computer monitor) and for this option you only need to follow the circuit in Fig.2a and the component list in Table 1 (ie, leave out the 680Ω resistor, leave jumper JP2 out but install a 1N4148 diode in the position marked "D1").

If you want to use composite video (eg, to suit a TV set with a "video in" terminal), you need both the 680Ω and 120Ω resistors, while JP2 can be wired permanently linked. As you will not need the VGA connector, you can leave that out and use the blank section of the rear panel for a panel-mounted RCA connector wired to CON5.

If you wish to switch between VGA and composite you should install a 2-pin header in JP2 so that you can con-

	VGA	Composite	Selectable VGA or Composite
R4	Leave Empty	680Ω Resistor	680Ω Resistor
D1	1N4148 Diode	120Ω Resistor	1N4148 Diode
JP2	Leave Empty	Permanent Link	Jumper or Switch

Table 1: components used for permanent VGA or composite video output or for the ability to select between the two.

nect a jumper or switch and use the components listed in the last column of Table 1. As explained last month, the video quality is not quite as good as the dedicated modes but it is still acceptable.

Another decision relates to how you plan to use the external input/output pins. As shown in the photographs, we used a right angle IDC header plug. This allows you to connect the Maximite to a variety of external circuits via an IDC socket crimped to a length of 26-way ribbon cable. This is ideal as the connector and cable are cheap and at the other end of the cable you can strip the wires and simply solder them to your test setup.

Another way of using this connector is to use female to male jumper leads to connect the Maximite to a solderless breadboard, as shown last month (page 36). The female end of the jumper wire can be simply pushed onto the pins of the IDC header and the other end plugged into the breadboard. However, be careful which pin is used – they're easy to mistake.

Instead of using an IDC header plug you could use two rows of vertical header pins. This will enable you to connect (via a matching header socket) to a second PCB mounted in the lid of the case which could hold specialised signal conditioning circuitry suited to your application. There is plenty of room in the case for components on this second board and the completed assembly would make a neat and compact package.

Construction

OK, now we get on with the fun part! If you are building the Maximite from the Altronics kit, it will come with IC1 pre programmed and pre-soldered to the PCB. This makes construction easy as the rest of the components are easy to solder.

If you are building the Maximite from the ground up you should refer to the PIC32 article in last month's issue for pointers on how to solder the chip. Of course, the PIC32 will need to be programmed so you will also need a PICKit 3 or similar programmer connected to CON3 to program the chip with the firmware, available from the Silicon Chip website.

The PCB uses fine tracks and IC1 can be damaged by static, so you need to take the standard precautions. Make sure that you and your soldering iron are grounded, use a temperature-controlled soldering iron and only hold it on a joint for a few seconds. Because the holes are plated through, it is difficult to remove components after soldering so make sure that the component is the correct type/value and is oriented correctly.

You should start with the low profile components and work your way up from there. The PCB is silk-screened with the component labels and placement so construction will mostly consist of just following the labels on the board.

Depending on the manufacturer of the capacitors that you are using, some may require that their legs are bent out to suit the PCB, which was designed for components with a 0.2-inch pitch.

When installing the crystal leave it sitting one or two millimetres above the PCB to prevent the chance of any of the underlying solder pads shorting to the crystal's metal case.

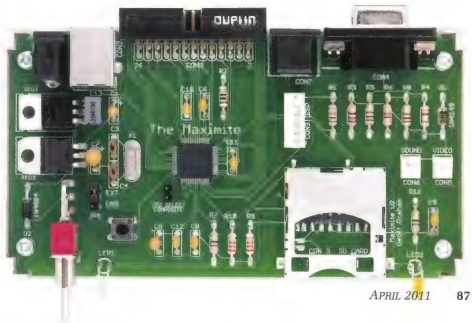
Normally you would not install anything in the position marked CON3. This is the programming interface described earlier and it will only be required if you need to program a blank PIC32 chip.

SD card connector

The SD card socket is a surface-mount device but it has two small pins on the underside that will match two holes in the PCB to ensure that the socket is correctly positioned.

When soldering the SD card socket you should make sure that you find and solder all the solder tabs – there are 16 in total. Two of these are very close together on the front left-hand corner of the socket (viewed from the front) and both should be soldered together to the same solder pad.

When mounting the voltage regulators (REG1 and REG2) you should bend the pins close to the component's body so that they fit in the small space. The PCB will have holes drilled so that you can screw the regulators to the board.



Here's what your completed Maximite should look like – it's shown here mounted in the bottom of the case at 1:1 scale. All components and connectors are on the one, double-sided PC board. The Altronics kit will have the PIC32 chip already soldered to the board and programmed ready for use. That's the only difficult part of the whole project!

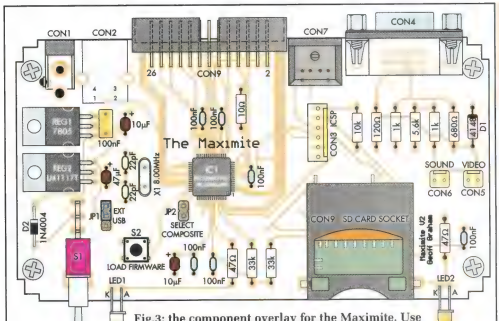


Fig.3: the component overlay for the Maximite. Use this in conjunction with the photo overleaf and the circuit diagram published last month. Note that this is a double-sided board – once you have soldered in a component, it is rather more difficult to remove than on a single-sided board. So get it right first time!

Errata from last month:
On the circuit diagram (Fig.1, page 33) the H-SYNC connection to the VGA connector is incorrect. It should connect to pin 13. Fig.2(a) and the PCB artwork are correct.

the pins fully from the bottom of the board. This will result in the LEDs being perfectly positioned with respect to the front panel.

Fig.7 provides the template for drilling the front panel and Fig.6 provides the front panel artwork. These templates and the panel artwork suit the Altronics H-0376 snap-together case.

We printed the artwork onto heavy duty adhesive backed paper (Avery 936067) and then covered the printed surface with adhesive clear plastic film of the type used to cover books. After you have trimmed the label you can stick it onto the front panel for a professional result. An alternative, tougher cover would be a heat laminated sleeve but these are harder to cut out and trim

The PCB is mounted in the case using 4mm long M3 screws (either metal thread or self tappers) at each corner. When you snap on the covers the result is a neat little box that contains a lot of power.

If you are likely to use a power supply higher than the specified 9V (eg, up to 14V) it would be wise to place a small heatsink under at least REG1. This could be a small piece of aluminium sheet, possibly bent into a "L" shape with an appropriately placed hole for the screw. However, in normal use (ie, 7-9V DC supply) this will not be required as the regulators operate well within their temperature range.

The Altronics VGA connectors have their pins set slightly closer together than other VGA connectors so, if you are using one of these, you will need to bend the two outer rows of connecting pins out by a millimetre or so before inserting the connector in the PCB. The connector will then sit flush with the board and can be soldered as per normal.

Finally, it is best to mount the LEDs after you have drilled the front panel. Bend the leads downwards 2mm from the body as shown below and position the LEDs in the PCB with the front panel temporarily placed in position and the LEDs poking through their respective holes. The longer lead of the LED (the anode) should be on the right hand side when the board is viewed from the front.

You can then tack-solder the leads into position on the top of the board before removing the front panel and soldering

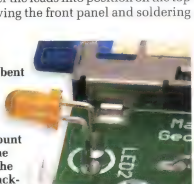


Fig.4: when mounting the LEDs the leads should be bent down about 2mm from the body with the longer lead (the anode) on the right when viewed from the front. Temporarily mount the front panel and use the hole drilled in it to hold the LED in place while you tack-solder the leads. This will ensure correct positioning of the component.

Testing

We will assume that your PIC32 has been programmed. Testing the Maximite is as simple as plugging it into a 9V DC power source (normally a plugpack). First make sure that a jumper is placed on the EXT position of JP1 so that the PIC32 can be powered from the external power supply.

On power-up, the firmware in the PIC32 will run a self test and after this has successfully completed it will turn on the green LED on the front panel. An illuminated LED is therefore an indication that all is OK and no light means that you have a problem.

If the LED does not come on you should first check the power supply voltages. Is the input between 7V and 14V? The output from REG1 should be 5V and the output from REG2 should be 3.3V. If these are correct you should then check all the capacitors for correct placement, value and polarity. Every one is critical and a misplaced capacitor could prevent the processor from starting up,

Also check the 47Ω resistor and the power LED for correct placement and polarity as the LED will not illuminate if these are incorrect. The final check is to examine IC1 for shorts or defects in soldering. This will require a high powered magnifying loupe and you should carefully check each pin.

With the firmware running you can check the video output by attaching a VGA or composite monitor and you should see the MMBasic prompt as shown in Fig.8. Finally plug in a PS2 keyboard and try typing in something. With the firmware running correctly any fault in these interfaces

Parts List – Maximite Microcomputer

1 PCB, code 06103111, 124mm x 69mm
1 Snap-together case 130 x 75 x 28mm (Altronics H0376)
1 8MHz crystal
1 DC power socket 2.1mm PCB mount (CON1)
1 USB B-type socket, PCB mount (CON2)
1 5-pin ICSP connector, PCB mount (CON3)
1 DE-15 (or HD-15) high density 15-pin female D connector (Altronics P3084A) (CON4)
3 2-pin headers (CON5, CON6, JP2)
1 6-pin mini DIN female connector (socket) (CON7)
1 IDC 26 pin boxed header PCB mount, 90° pins (CON8)
1 SD card reader socket (Altronics P5720) (CON9)
1 3-pin header (JP1)
1 Toggle switch SPDT 90° PCB mount (S1) (Altronics S1320)
1 Micro tactile pushbutton switch (S2)
4 M3 metal thread screws (or self-tappers), 4mm long

Semiconductors

1 PIC32MX695F512H-80I/PT or PIC32MX795F512H-80I/PT microcontroller (available from www.microchipdirect.com) [IC1]
1 7805 5V voltage regulator (TO-220) [REG1]
1 LM1117T-3.3 3.3V voltage regulator [TO-220] [REG2]
1 1N4148 general purpose low power silicon diode [D1]
1 1N4004 general purpose silicon power diode [D2]
1 Green LED, 3mm [LED1]
1 Red LED, 3mm [LED2]

Capacitors

1 47µF 6.3V tantalum
2 10µF 16V tantalum
7 100nF ceramic or MKT
2 22pF ceramic

Resistors (0.25W 5%)

2 33kΩ 1 10kΩ 1 5.6kΩ 2 1kΩ 1 680Ω
1 120Ω 2 47Ω 1 10Ω

could only be related to components specific to the interface and should be easy to diagnose.

USB interface

Before using the USB interface you will need to install the SILICON CHIP USB Serial Port Driver on your computer (available from the SILICON CHIP website). This will work with all modern versions of Windows and full instructions are included with the driver, so installation should be easy. The Maximite uses the standard CDC protocol and drivers are also available on the internet for the Mac and Linux operating systems.

The Maximite will be listed on your Windows computer in the Device Manager under Ports (COM and LPT) as "Communications Port – SILICON CHIP USB Serial Port" with a specific COM port number. When you configure the serial emulation software on your computer you will need to specify this number to establish communications with the Maximite. If the software also needs to know the communications parameters you can specify 9600 baud with one stop bit and no parity.

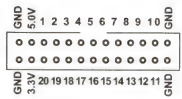


Fig.5: the input/output connector used by the Maximite. This view is from the back of the unit and should be referred to when connecting to external circuits. The 5V and 3.3V pins can supply about 100mA for powering external circuits.

For the serial emulation software on Windows we recommend that you use the free, open source Terra Term (http://logmett.com). This emulator allows you to easily send a file over the serial interface and capture data coming in the reverse direction. Sending a file lets you upload a BASIC program to the Maximite where it will be received and stored in memory as if there was a high speed typist on the other end typing in the program.

This makes it possible to enter and edit your BASIC program on your Windows computer (where you have the convenience of a mouse and cut and paste) then send it via Terra Term and the USB to the Maximite where you can test it. Note that for this to work you need to configure Terra Term for a delay of 50ms per line (Settings > Serial Port).

Power supply

The Maximite is intended to be powered from a 9V DC plugpack but the supply voltage can be anywhere in the range of 7V to 14V. However, at the higher end of the range REG1 will be required to dissipate a lot of heat. We mentioned earlier a heatsink under REG1 to assist in this regard.

But if you plan to power the Maximite from, say, a 12V battery in an automotive environment it would worth placing a 33Ω 5W resistor in series with the power supply line to drop the supply voltage and dissipate some of the heat outside the Maximite's case.

You could also consider replacing REG1 with a more robust (and expensive) regulator like

Capacitor Codes

Value	µF Value	IEC Code	EIA Code
100nF	0.1µF	100n	104
22pF	NA	22p	220

Resistor Colour Codes

	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	2	33kΩ	orange orange orange brown	orange orange black red brown
❑	1	10kΩ	brown black orange brown	brown black black red brown
❑	1	5.6kΩ	green blue red brown	green blue black brown brown
❑	2	1kΩ	brown black red brown	brown black black brown brown
❑	1	680Ω	blue grey brown brown	blue grey black black brown
❑	1	120Ω	brown red brown brown	brown red black black brown
❑	2	47Ω	yellow violet black brown	yellow violet black gold brown
❑	1	10Ω	brown black black brown	brown black black gold brown

the LM2937. This is pin-for-pin compatible with the 7805 but is more suited to the auto environment where large voltage spikes are prevalent.

One other point to keep in mind is that, unless a plugpack specifically states it has a regulated DC output, the no-load output voltage of the vast majority of plugpacks is significantly higher than their nameplate states – we've seen them as much as double! The theory is that the voltage will drop to around the right level at full load. But the Maximite draws so little current most plugpacks will never get down to that, so be warned!

If you wish, you can power the Maximite from a USB power source by moving JP1 to the USB position. This might be useful if you will be using the Maximite as a peripheral to a desktop PC – when you plug the Maximite into the USB it will be automatically powered up.

Fig.8: if you see this prompt on your screen you can be assured that both the microcontroller and the video output circuitry are working correctly.

Getting started

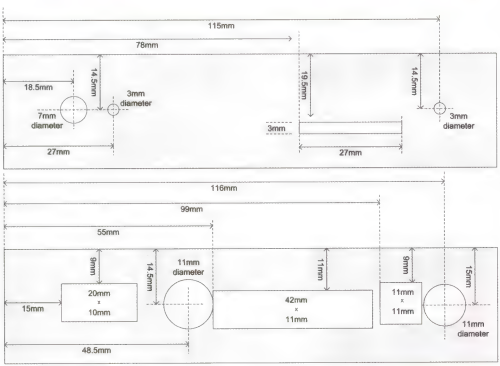
So, now you have everything you need to build the Maximite and start experimenting with it. Next month we will go into more detail on how to use it but in the meantime you can get started by downloading the "Maximite User Manual" from the SILICON CHIP website. This provides the definitive summary of the Maximite and MMBasic.

The download also includes some sample programs that you can run to get a feel for the potential contained in this tiny but powerful computer.

For up to date errata, notes and new firmware for the Maximite go to http://geoffg.net/maximite.html SC

Fig.6: the front panel artwork (shown full size) can be copied onto adhesive paper and then covered with a thin adhesive plastic sheet (of the type used to cover books) or printed then sead with a heat laminator. After trimming the result will be a professional looking front panel.

Fig.7: these are the front (top) and rear (below) panel cutouts for the Maximite shown full size and to scale. You can photocopy these (without breaking copyright) and use them as templates to drill and cut your panels. They're designed to suit the Altronics H-0376 snap-together case. The power switch and the SD card slot are the only critical cutouts as these components are soldered to the PCB. You should check the cutouts against the actual components that you are using as the size (and therefore positioning) might vary between manufacturers.



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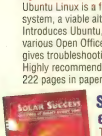

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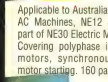

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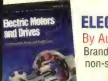

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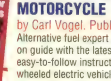

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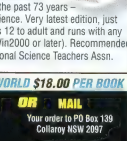

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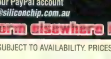

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By RODNEY CHAMPNESS, VK3UG

The STC 504: a 5-valve table radio from 1939

Manufactured just before World War 2, the STC 504 is a 5-valve table receiver housed in a very attractive timber cabinet. It's an interesting circuit that performs well, especially after a few minor tweaks to its AGC system.

THE VERY FIRST radios used breadboard construction, then came the coffin style before the large consoles of the 1930s and 1940s became dominant.

During the 1930s, compact sets that could be placed on table tops were also developed, although they were still usually too large for a mantelpiece. Many of these sets used a tuning dial located on a sloping panel on the top of the cabinet, which meant that they had to sit on a table or low cupboard.

These days, it's hard to envisage such sets sitting on a lounge-room table away from the wall where power, antenna and earth were available. However, many were positioned that way and became the focus of the family's entertainment.

There is no doubt these table sets were much more attractive than the average mantel set. For a start, they were usually housed in good-quality veneered timber cabinets. And although their sound quality would have been inferior to the consoles with their well-baffled 300mm (12-inch) loudspeakers, they were considerably better than the mantel receivers.

This month, we take a look at a typical table radio from the era, the 1939 STC 504. It is a mains-powered 5-valve superhet design that covers the broadcast band only (ie, no shortwave).

The STC 504 5-valve receiver

The unit featured here is one that I have on loan and is quite an interesting set. It's housed in a nicely-finished timber cabinet which measures 460mm long, 255mm high and 270mm deep. The complete set weighs 10kg, so it's no lightweight.

Unfortunately, the set is no longer completely original. The chassis had been overhauled several years ago, while the cabinet had only recently been restored. This restoration work has not been completely successful though, as explained later.

An unusual feature of the set is the mounting arrangement used for its 200mm (8-inch) speaker. This is attached to a fairly thick baffle which is mounted at an angle across the front lefthand corner of the cabinet. This baffle is quite effective for such a "compact" cabinet and contributes to the set's sound quality.

The dial-scale is rather elaborate in appearance and is mounted on the righthand side. As with many other dials of the era, it looks quite impressive when lit up at night.

The three controls are mounted underneath the dial escutcheon. From left to right, they are: Tone, Tuning and Volume.

A glance inside the back shows just how tightly packed the cabinet is, with the chassis occupying the remaining space next to the loudspeaker. Apparently, the cabinet didn't have a back which was not uncommon in those days.

Circuit details

Let's now take a look at the circuit details – see Fig.1. It's a typical 5-valve superhet design for the era, although there are a couple of quirks.

As shown in the photos, the an-

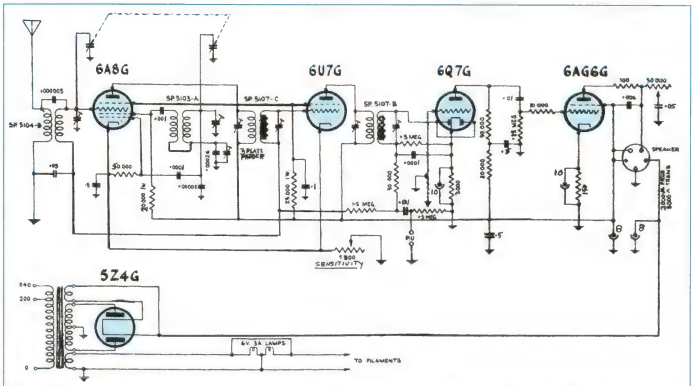


Fig.1: the circuit is a fairly typical superhet design employing five valves, a 450kHz (later 455kHz) IF stage and an electrodynamic loudspeaker. The sensitivity control is unusual and was difficult for the average user to master.

tenna terminal is at the far left on the back of the chassis. From there, the antenna lead goes through a hole in the lefthand end of the chassis and travels along this external edge until it re-enters the chassis near the front. This arrangement was used in many valve receivers and was done to keep the antenna lead away from the IF (intermediate frequency) amplifier. This reduced any chance of strong marine radio signals (which were close to the IF) breaking through into the IF stages.

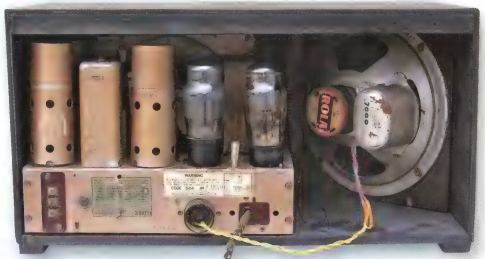
The following antenna-tuned circuit is quite conventional, with the resulting signal applied to the grid of a 6A8G converter valve. The oscillator is a little unusual in that padder feedback was used to ensure more reliable oscillation than a conventional circuit often gave.

The coils for the antenna and oscillator tuned circuits are both aircored. As a result, adjustment of the frequency range and tracking must be done using the oscillator trimmer across the tuning capacitor and the padder capacitor. The antenna-tuned circuit can only be peaked at the high-frequency end of the dial.

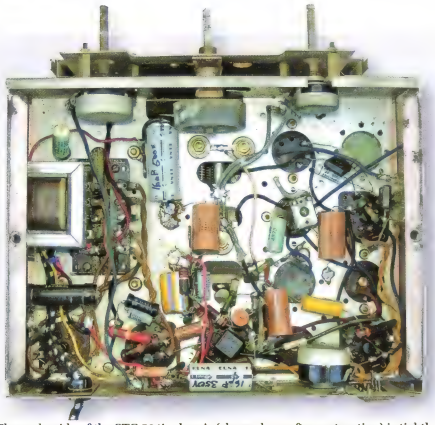
It's interesting to note that some time in 1939, STC changed the intermediate frequency used for their sets from 450kHz to 455kHz. However, although STC changed the IF centre frequency, there was no need to change the IF transformers themselves. That's because most IF transformers centred on 450kHz will tune easily from around 430kHz to 480kHz without any modification.

The resulting signal from the first IF stage is applied to a 6U7G IF amplifier, before being fed to the second IF transformer. The signal is then fed to a 6Q7G (a triode duo-diode valve) where it is detected. AGC is also obtained from the detector.

From there, the detected audio signal is fed to a 0.5MΩ volume control, after which it is amplified by the triode section of the 6Q7G. The amplified signal is then fed to a 6AG6G audio



This view shows the back of the set before restoration. The original electrodynamic loudspeaker had already been replaced with a permanent magnet speaker at some time in the past.



The underside of the STC 504's chassis (shown here after restoration) is tightly packed with components, although most parts are easy to access. The sensitivity control on the rear panel (bottom right) has been made redundant, to make the set easier to adjust (see text).

output valve which in turn drives the electrodynamic speaker.

Power supply details

The power supply is quite conventional. The primary of the transformer is tapped at 200V and 240V, which covered all the likely voltages used in Australia at that time. Its high-voltage CT (centre-tapped) secondary drives a 5Z4G rectifier and its output is fed through the field coil of the electrodynamic speaker to derive the HT line. Two 8µF electrolytic capacitors (one either side of the field coil) provide additional filtering.

Like most receivers that use electrodynamic speakers, the power consumption is relatively high at 52W. One real advantage of using a 5Z4G rectifier is that it has an indirectly-heated cathode which warms up and commences conduction at about the same time as the rest of the valves. As a result, the peak voltage across the filter capacitors is much lower than it would be if a directly-heated 5Y3G rectifier had been used.

Cabinet restoration

As stated, the cabinet has only recently been restored but only after someone else had "had a go" at it. Unfortunately, the outside of the cabinet had been rubbed down to get rid of imperfections but whoever did it was unaware of just how thin the veneer is and had sanded it down too far. This has exposed the lower-quality timber beneath the veneer.

This sanding down had been done with relatively coarse sandpaper across the grain. As a result, the most recent cabinet restorer had to be very cautious as to how he approached the job. In the end, he used some fine French polishing-grade steel wool to restore the surface to a good, but not perfect, condition (some of the sanding marks are still visible but only if you are looking for them).

The cabinet was then given a coat of "Golden Oak" stain after which it was finished with a pressure pack of 30% nitro-cellulose lacquer. Six coats were applied to the top to fill the grain of the wood, while three coats were applied to the sides and front. The inside of the cabinet was spray painted matt black, as was commonly done with timber cabinets of that era.

The knobs were a little grubby and were given a wash in soapy water. Once dry, they were polished using automotive cut and polish compound, which brings bakelite up looking almost like new. One knob is obviously a replacement though and doesn't match the other two. The other two are originals, so it would be quite practical to get one of the members of the HRSA who specialises in making replica knobs to make another.

Chassis restoration

Before applying power to the set, I went through my usual routine of checking the power transformer and the HT line. This involves checking for shorts and excessive leakage in the transformer using a high-voltage insulation tester, especially between the primary and high-voltage secondary windings and the chassis.

Similarly, the isolation between the HT line to the chassis was also tested. These tests all indicated that the set would be safe to turn on after I'd checked all the other work that had been carried out.

In fact, this particular receiver seems to have had a rather chequered history of restoration, with bits and pieces carried out by several people. And although most of the work had been done to a reasonable standard, a few things did strike me as being a little careless. A little extra effort and the set would have been safer and a easier to service.

First, all of the electrolytic and paper capacitors had been replaced. However, a couple of UCC paper capacitors had been used and these have been known to become intermittent and/or leaky over time. I replaced them to avoid future problems.

In addition, the automatic gain control (AGC) system is not at all like the circuit and I'm not sure if this is a factory modification or if it was done by the restorer. It has been altered so that the AGC is now a delayed AGC system. After some deliberation, I modified it even further to make it a little more effective.

In fact, the AGC circuit is now very much like that shown in Fig.4 on page 92 of the June 2010 issue.

Sensitivity control

A slightly unusual feature is the inclusion of a "sensitivity" control, which is the potentiometer located in the centre-bottom of Fig.1. As the wiper is moved from its extreme righthand position to the left, the sensitivity of

the receiver will increase. Eventually, a position will be found somewhere along it travel where the sensitivity is at a maximum.

Note, however, that this occurs before the minimum resistance point (0Ω) is reached. That's because, at 0Ω, the converter and IF amplifier valves will have no cathode bias, as the cathodes will effectively be at chassis earth.

In addition, the return for the detector and AGC diodes is at a positive voltage, as set by the voltage across the 6Q7G's 3kΩ cathode resistor. As a result, this voltage is applied down the AGC line to the front-end valves.

In my opinion, the Sensitivity control was not a particularly smart design feature by STC, as most people would not understand how to set this control correctly (it's a screwdriver adjustment on the back panel).

The AGC circuit in this particular set has been modified to overcome the "positive voltage" problem with the AGC line. In addition, a previous restorer had fitted a 330Ω resistor in series with the wiper of the sensitivity control, so that the valves still have cathode bias at the minimum setting.

It was quite a good idea but that resistor value was too high to obtain maximum gain from the front-end. As a result, I substituted a 150Ω resistor and the bias is now correct for maximum gain with the control fully rotated to the lefthand end. This effectively makes the Sensitivity control redundant.

Obscured values

One of my pet peeves is components that have been installed so that their values are obscured. Unfortunately, the previous restorer had done just that, which is annoying.

It takes so little effort to orientate components so that their values can be seen that I cannot understand why it's not done – it makes life so much easier when troubleshooting or checking a circuit.

Speaker replacement

At some time in the past, the electrodynamic speaker had been replaced with a permanent magnet unit. This replacement and the associated modifications to the HT filter circuit had been quite well done and under normal operating conditions, was quite satisfactory.

A compact chassis fitted with an elaborate dial scale is used for the STC-504 5-valve receiver. The three controls beneath the dial scale are (from left to right): Tone, Tuning & Volume.

In place of the field coil, the previous restorer had installed a 14 Henry choke and a series wirewound resistor, giving a total of 2kΩ in series in the HT supply line. This matches the resistance of the original speaker's field coil.

However, if the speaker plug had been removed when the set was operating, the plate of the 6AG6G would have had no voltage on it. Conversely, voltage would have still been present on the screen and so the valve would have been destroyed quite quickly due to excessive screen current being drawn.

To eliminate this problem, I rewired the socket and plug so that removal of the plug removes HT from all sections of the receiver except for the first HT filter capacitor.

The power cord was also a problem, being retained only by a knot in the lead just inside the chassis. That may have been acceptable back in 1939 but it's certainly not acceptable today. This primitive anchoring scheme has now been replaced with an approved cable clamping system.

Finally, close inspection of the wiring around the 6Q7G revealed a lump of solder between a couple of the valve pins. It was removed and fortunately hadn't caused any problems.

Test & alignment

With everything under the chassis now looking shipshape, it was time to check the set's performance and do an alignment.

The first thing to do was to see if the set actually worked and carry out some voltage checks, so I connected an antenna and earth and switched on. The dial lamps immediately came on and shortly after the valves started to glow and noise could be heard from the speaker. The various voltages around the receiver were all within expectation, ie, around 220-250V on the plate circuits and around 100V on the screens. The voltages across the cathode resistors were around 2.5V on the RF valves and 4V across the 6AG6G's cathode bias resistor.

Next, I tuned across the broadcast band and a number of stations were heard, so the set appeared to be working. As a result, I disconnected the antenna and attached my RF signal generator to the antenna input. With

The top of the chassis is tightly packed with the major parts. Metal shields are fitted to the converter, IF and detector/triode valves, while the mains cord is now firmly anchored with a cordgrip grommet in place of the original knot.

the tuning gang vanes closed, I applied a strong modulated 455kHz signal to the set and was rewarded with audio from the speaker. I then slowly reduced the signal generator's output, at the same time carefully adjusting each of the four IF trimmers for best audio output.

Note that one trimmer in each IF transformer is at the full HT voltage and therefore considerable care is needed to make sure the screwdriver doesn't slip and short the HT to the chassis (or that you don't get a shock). All four adjustments peaked easily and the performance noticeably improved.

The front-end tuned circuits were next and these are first adjusted at the low-frequency end. This initially involves setting the signal generator to 600kHz, then tuning the receiver to 600kHz on the dial. The padder capacitor is then adjusted until the signal generator's signal is heard at this dial location and then carefully adjusted for peak output.

That done, the generator is set to 1400kHz and the receiver tuned to 1400kHz at the high-frequency end of the dial. The oscillator trimmer on the top of the tuning gang is then adjusted for peak output, after which the

The parts around the detector/first audio amplifier socket are somewhat crowded together.

procedure at both the low-frequency and high-frequency ends of the dial is repeated several times, until there is no need for further adjustment.

Finally, the signal generator is removed, an antenna connected and the set tuned to a distant station close to 1400kHz. The antenna trimmer under the chassis is then peaked. There is no corresponding adjustment at the low-frequency end of the dial but the sensitivity of the receiver is reasonably consistent across the band.

Once these alignment adjustments had been completed, the set performed quite well although its worth noting that both the selectivity and gain of the IF amplifier stage is inferior to slightly later sets with iron-dust cored coils.

Gremlins

Having completed the alignment, a couple of gremlins suddenly reared their heads. The first fault was an occasional loud crackling sound from the speaker. It remained with the antenna removed but disappeared when the volume control was turned down.

This indicated that the problem was in the front-end and replacing the 6A8G fixed the problem.

The second fault occurred during final testing. I had the set upside-down to allow access to the wiring when suddenly the HT (high tension) rose to quite a high level, indicating no current was being drawn. At the same time, the dial lamps went out and there was a burning smell.

I hastily switched the set off, turned it over and checked the power transformer. The section where the filament winding was wound was quite hot and some of the wax had melted.

In the end, this fault was tracked down to one of the dial lamp sockets, which was intermittently shorting to earth. Replacing it fixed the problem but it's a good thing that I was on the spot when this fault occurred, otherwise it could have destroyed the power transformer. Having fixed these two faults, there were no further problems and the set worked well.

Summary

This is a good-looking set with better than average audio, due to good speaker baffling and a relatively broad IF bandwidth. However, the AGC and sensitivity control really weren't quite as well-designed as they could have been. As stated above, the sensitivity control is now superfluous following a few modifications to the AGC system.

The chassis also looks like it has been designed to suit several different receiver layouts. For example, there is provision for an additional tuning gang section, which suggests that a different receiver with an RF stage used the same chassis. There are also two holes in the chassis which have been covered over and these probably accepted additional components.

In summary, this is an excellent example of the state of the art just prior to World War Two. It performs well and is certainly worth having in a collection. SC

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Query on over-range for LC meter

I've just built an LC Meter kit (SILICON CHIP, May 2008) and have successfully calibrated it for capacitance. However, there's a problem with the inductance mode.

When S1 is set to the inductance position, the meter immediately produces an "Over Range" message. Placing the shorting bar across the test terminals and pressing S2 does zero the reading (initially 0.00µH, straying upward to 0.02µH) but the "Over Range" message immediately reappears when the shorting bar is removed.

Can you please suggest what might be the problem? (P. R., Maroochydore, Qld).

● The LC Meter does give an "Over Range" indication in the Inductance measuring mode when there is nothing connected to the test terminals. That's because the meter sees a very high impedance across the terminals, which it assumes to be a very high inductive reactance. However, as soon as you connect a physical inductor across the terminals, you'll find that the meter will indicate its inductance value, as it should.

This is not a fault. It's just a result of the way the meter works. In capacitance mode, it interprets a very high impedance across the open terminals as a very small capacitance but in inductance mode it interprets the very high impedance as a very large inductance – hence the "Over Range" indication until you connect a smaller physical inductance.

Milliohm Adaptor zero set-up error

Thank you for your Milliohm Adaptor for DMMs (SILICON CHIP, February 2010); another contribution in your seemingly endless arsenal of useful measurement projects. I built the adaptor as described and calibration was straightforward with gain resistance, in this circuit 680Ω + VR4, very close to the calculated resistance, as per the AD623 data sheet, for a gain of 100.

However, I find that the output drops off at the lower end, in particular on the 1mA/10Ω range. A 1.0Ω resistance reads as about 85mV (0.85Ω) while on this range the output drops to zero for a resistance of 0.1Ω. Could you comment on this and if confirmed perhaps suggest any ways to improve the response?

Maybe it should also be mentioned that, at the upper end of the scales, the measurement ranges go very little beyond 1Ω or 10Ω before clipping occurs, so you cannot measure any resistance higher than about 1.1Ω on the 10mA/1Ω range. (K. R., Hervey Bay, Qld).

● We are puzzled by your report that the output of your Milliohm Adaptor "drops off" at the low end, and drops to zero for an unknown resistance of 0.1Ω on the 1mA/10Ω range. This sounds as if the "set zero" control may be set too high, which would have this effect. We can't think of any other cause in fact, so you should re-check the zero setting using using trimpot VR5, as described in the article.

You are quite correct in your note that the upper end of both ranges extends very little beyond 1.1Ω and 11Ω. This is due to the voltage swing limitations within the AD623 when operating from 8.4V and with a gain

A Corner Reflector Antenna For UHF TV

I built the Corner Reflector Antenna for UHF (SILICON CHIP, June 1991) some six years ago. Not being happy about having to paint it and the way the coax cable had to be connected by soldering it to the PC board, the antenna was put in to the too-hard basket and forgotten.

Now necessity has finished the project. I soldered a PCB-mount F connector to the PCB and this made it possible to connect aluminium RG6 twin-shielded coax cable to the antenna with ease.

The antenna system is now working very well with one set-top box, an 81cm CRT TV and a new 66cm Sanyo flat screen HD TV. Both pictures are perfect, with no pixellation evident in dry or wet weather.

The antenna is supposedly one kilometre out of adequate coverage according to the ABC frequency information on the internet. But signal strength as indicated on the Sony TV is two bars down on all but two channels which are three bars down on signal strength.

What I would like to know is how much trust can be put on the indication of the TV signal strength indicator? Or an after-market signal strength meter? How can one know that the signal is in the "digital window"? Also can you please explain bit error ratio and modulation error ratio and how they fit in to signal strength and with what and how they are measured? (G. M., via email).

● We simply don't know how accurate the signal strength indication is on an STB or after-market signal strength meter. However, the fact that the signal strength reading from a TV or STB is comparative rather than in microvolts means that it is indicative only.

In any case, you already know that your signals are within the "digital window" since your reception is free of pixellation and presumably has no sound drop-outs, particularly in wet weather.

We suggest that you read our articles on digital TV in the March & April 2008 issues and in March 2010.

Memory Size On Storage Devices

I am trying to find out why the memory size of hard drives, USB sticks and memory chips is actually somewhat less than the amount indicated on the packaging and why manufacturers are allowed to get away with it. When you click on the device and check properties, the size sold is the byte size [X x 10^9 bytes] and not the GB size as indicated. For example:
(1) a 4GB USB stick is around 4,100,000,000 bytes and 3.89GB;
(2) a 16GB SD card is around 16,010,000,000 bytes and 14.9GB;
(3) A 750GB hard drive is around 749,500,000,000 bytes and 698GB.

I did some quick checks on my trusty calculator and found the discrepancy to be around 7.5%. Blank CDs sold as 700MB [702] are correct because that's their true capacity in MB. Properties shows 736,000,000 bytes and 702MB.

Why aren't other storage devices rated the same way? (S. K., Penshurst, NSW).

● Because memory addresses are bit fields, historically memory and storage capacities have been related to powers of two. As a result, a kilobyte is traditionally considered to be 1024 (2^{10}) bytes, a megabyte 1,048,576 (2^{20}) bytes and so on. RAM always has been (and still is) sold on this basis. For a long time, hard disks and other storage devices were also measured this way.

About 10 years ago, at least one manufacturer decided that 1MB = 1,000,000 bytes. This allows them to sell 5% smaller drives than their competitors but claim the same capacity. This probably gave them a few tens of cents extra profit per unit compared to their competitors.

Before long, all hard drive manufacturers were using this trick to calculate their drive sizes. Unfortunately, it has stuck and when FLASH memory came along they decided to use this scheme as well. Since the computer still uses powers of two to calculate the capacity (as this is how it addresses the data), the reported capacity is lower than what you expect.

It's even worse now with gigabytes since the discrepancy is larger. $1 - 1000^3/1024^3 = 7\%$ less. For terabytes, $1 - 1000^4/1024^4 = 9\%$ less. Unfortunately, this is unlikely to change.

of 100. Most constructors will find this limitation quite acceptable in a project designed to measure only very low resistances.

EGO analyser is obsolete

I have just resurrected my PC-driven EGO Analyser ("Electronics Australia", January & February 1996) which I made up and used some five years ago with great results.

For some reason it now no longer works. I have deleted and reloaded the EGO software and checked for volts and continuity in the relevant places with no problems evident. I have built the Smart Mixture Display (SILICON CHIP, April 2004) but as you are aware this does not give any detailed output.

Are you going to make up something similar to the PC-driven EGO analyser in the future? (F. W., via email).

● We have no plans for a project along the lines of the EGO Analyser. Our most recent "analyser" project was the OBD interface for a laptop computer. It gives far more information than the EA project but the catch is that your car must have an OBDII port.

Making speed control more progressive

I have successfully assembled your 230V 10A Motor Speed Controller (SILICON CHIP, May 2009) which runs fine on a drill etc but I am using it to drive a 650W router motor, in turn driving a cutter on a 3-axis engraver. Unfortunately, the speed starts nice and slowly but then increases to full speed too quickly as the pot is rotated.

Is it possible to rearrange the pot circuit so that the increase in speed is spread over the full rotation and not just a portion of it? (A. W., via email).

● The potentiometer range depends on the feedback gain setting (VR2). When this is set, you may need to change the 1kΩ and 8.2kΩ resistors in series with VR1, to alter the potentiometer's range. Possibly two 20kΩ trimpots could replace these resistors and then be adjusted to obtain the desired range for VR1.

Note that these trimpot adjustments must be made on a trial and error basis **with the mains power to the controller off (ie, the mains plug removed from the wall socket)**. These adjustments will affect the feedback gain setting.

Commodore 64 power supply replacement

I recently dragged out my old Commodore 64 computer to show my kids how "modern" these computers really were. I didn't realise how slow the C64 was but she is still a beaut machine!

Anyway, I need to power it with a new power supply as the old one stopped working. The problem is that the power supply provides two different voltages; one AC and the other DC in the same plug but on different pins.

One is 5V @ 1A DC. This is easily met by using a Jaycar Cat MP-3480 or similar. However, the other one is 9VAC 18VA. This is proving to be a problem as I can not find a suitable AC adaptor.

Would you have any ideas as to where I may be able to purchase such a supply or even try to make one? (J. R., Stratton, WA).

● One approach would be to just house a 9V transformer (eg, 2165) inside an earthed metal case. Secondly, depending on how the 9VAC is rectified, you may be able to feed a 12V DC plugpack in and get the same result.

Query on minimum Dazzler brightness

I built the LED Dazzler project and while it works, I can not turn the LED brightness all the way down using potentiometer VR1 (ie, once VR2 is set so that at the maximum setting, 2.8A is delivered to the 10W LEDs). With VR1 at minimum, there is still about 150mA flowing.

Why is this and can I do anything about it? (J. J., via email).

● It is because the minimum and maximum current levels are determined by a resistance ratio which is

set by VR1 and some fixed resistors. While the fixed resistors should be within 1% (in fact they will probably be closer than that), VR1's tolerance will be more like 20% and if it is at the lower end of the range, it may not be able to adjust the control voltage over a large enough range.

The easiest solution is to shunt the 8.2kΩ resistor in series with VR1 with a 150kΩ resistor and then re-adjust VR2. This will increase the control range of VR1 by about 5%, allowing you to turn the current down to zero. If that still isn't enough, reduce the value of the shunt resistor slightly.

Digital UHF data link wanted

As a long-time subscriber to a great magazine, I need some technical guidance. My problem is that my new TV has a Toslink audio output on one side of the room and my Bose amplifier is on the opposite side with no suitable cable access with brick and concrete in the way.

My immediate thoughts are to fabricate an IR or wireless link from the TV to the Bose amplifier but I'm unsure about the IR link ability to handle the digital audio bit rate. So can I use sections of two previous SILICON CHIP projects: the Two-Way SPDIF/Toslink Converter (June 2006) and the Infrared Audio Link (December 2007)? The idea is to convert Toslink to SPDIF then transmit IR to the IR receiver and then convert S/PDIF to a Toslink signal.

Secondly, is a commercial AV sender capable of transmitting and receiving a S/PDIF signal? (B. W., Hornsby, NSW).

- The bandwidth required for a digital audio signal depends on the content it is carrying. For a CD it is a 5.64MHz biphase-encoded signal. For a DVD it depends on whether the audio is PCM or a compressed format like Dolby Digital or DTS. It will typically be at least 6.144MHz.

Because the Infrared Audio Headphone Link for TV (December 2007) is designed to transmit analog audio using 90kHz modulation, it will be unable to pass a high-frequency digital signal like S/PDIF. In fact, it would be very difficult (but probably not impossible) to transmit digital audio using infrared light due to the data rate required. It might work if the light is sent along some kind of fibre – but that wouldn't solve your problem!

A UHF link would be more suitable, however it would not be able to stand much interference. Wireless video gets a bit fuzzy if interference is present but even the occasional single-bit error will make a digital audio stream unusable.

We spent a while discussing whether one could, in theory, send an S/PDIF stream with a wireless video transmitter, since typical PAL video bandwidth is only 5MHz. Then somebody remembered that we actually have a wireless video transmitter in the office and in the end it was easier to just plug it in and see what happened.

With a direct line-of-sight between the two units it did seem to work. The unit we tested is a 2.4GHz Wavecom Sr which is quite old and unlikely to be available now. However, this suggests that 2.4GHz and 5.8GHz wireless video links could be suitable for sending an S/PDIF signal. With that unit we found that a person walking between the transmitter and receiver would cause errors in the signal but a more modern system may have better signal integrity. It certainly is feasible to transmit a digital audio signal across a room in this manner.

As you suggest, it will be necessary to convert the Toslink to S/PDIF for transmission and possibly back to Toslink at the other end. Our Two Way SPDIF/Toslink converter is certainly suitable but we have since published a better option, the two Toslink-S/PDIF Audio Converters in the October 2010 issue.

These are available in kit form from Altronics (Cat. K5174 and K5175) and since the two halves are separate, you won't end up with redundant sections at each end. You may even be able to power these units from the same plugpack as the wireless transmitter and receiver, as they draw very little current.

The signal level output from the TOSLINK to S/PDIF converter should be suitable for driving a video transmitter although you may get better performance with a wider voltage swing, which can be achieved by altering the resistor ratios in the output divider.

LED signal flasher unit

Recently, I had a major problem with the turn signal indicators on my motorbike (the bike is a 1984 model). After investigating, I discovered one of the lamp holders had shorted the centre conductor to the body. This then destroyed the original flasher unit.

Low Capacitance Adaptor Won't Null

I built the Jaycar version of the Low-Capacitance Adaptor For DMMs (SILICON CHIP, March 2010) and it won't null. When no capacitor is connected, the lowest value I can get by adjusting the null is 21mV on setting A (2.2mV on setting B, 0.2mV on setting C).

It measures the capacitances correctly once a capacitor is connected but of course, you cannot measure below the incorrect null point. Any ideas? (A. N., via email).

- We are not aware of any differences between the components in the Jaycar kit for the Low Capacitance Adaptor and the component values as published, so we must assume that there are no relevant differences (nominally at least).

That being the case, possibly the "stray" capacitance between the capacitor binding posts in your unit is slightly but significantly lower than the minimum capacitance of your nulling trimmer capacitor VC1, so that a true null cannot be achieved. Perhaps this is due to VC1 having a slightly higher minimum capacitance than the nominal 3.0pF or because the binding posts in your unit have a slightly lower stray capacitance between them than is usual due to the plastic used in them or the case end panel.

Regardless of the exact cause, the way to allow a true null to be achieved is by connecting a very low value NP0 ceramic capacitor between the rear of the capacitor binding posts, inside the case and on the top of the PC board. We suggest you try a 1.5pF capacitor first and then see if you can achieve a null using VC1.

Hopefully this will be so but if not you could increase the value to 2.2pF or 2.7pF.

Converting A Torch To Use LEDs

When we marshal landing aircraft at night, we use marshalling wands. These consist of a basic torch utilising a red globe encased in a conical wand. Unfortunately, these deplete their two 1.5V batteries often on the flight line, which can be dangerous.

I want to replace the red globe in the torch with LEDs, which would illuminate the whole cone and reduce the battery demand. Do you have a circuit for such? (R. B., Nowra, NSW).

● A 1W LED torch that used two D cells in a standard torch was published in November 2003. Your conical wand should light up with the 1W LED facing upward.

Note that the Luxeon star LEDs are available in red which will be more efficient than using white LEDs with a red filter. See **www.altronics.com.au** for red 1W LEDs or the Alternative Energy Association website at **www.ata.org.au**

The PCB is available from **www.rcsradio.com.au** while the ZX-SC100N8 is available from Mouser: **http://au.mouser.com**

The ZXT13N50DE6 is also available from Mouser. The ZXT13N20-DE6 in the parts list appears to be unavailable but the ZXT13N50DE6 is suitable. The Schottky diode type is not critical but should have a 1A rating.

LED torches are also available commercially. For example, see **www.jaycar.com.au** or **www.ata.org.au**

Notes & Errata

USB Data Logger (December 2010 - February 2011): the specified inductor has been found to be not suitable for the frequencies at which the regulator operates. This can cause excessive current to be drawn at start-up and with low battery voltages. As a result, it should be changed to a 47µH high frequency ferrite choke (Jaycar LF-1100) which fits in its place.

Also, a new version of the firmware is now available (v9.92) which, in combination with the new inductor, reduces the current drawn at start-up as well as fixing some other bugs.

LED Dazzler (March 2011): the parts list and circuit diagram show two 22Ω resistors but the PCB overlay has these as 10Ω. 10Ω is correct although 22Ω will also work.

As a result, I decided to fit new modern LED indicators rather than play with cheap junk again. Super Cheap Auto had the right ones for $100 for all four and I was in luck; I had a spare flasher unit from another bike I had scrapped for parts.

They fitted easily and everything worked perfectly. Even the old 1980's flasher unit had no problem with the LED lights. They flashed at a normal rate. Talk about future-proofing a product. This then led me to want a spare flasher unit again but for the life of me I can't find a circuit that will work with this particular arrangement.

The flasher is a 2-wire unit with power from the battery going to one pin of the unit. The other pin then goes to the turn signal switch on the handle bars and from there it runs to the turn signal LEDs and to ground. Unfortunately, the original flasher is potted in epoxy so there is no looking at the circuit design.

Has Silicon Chip ever done a project or design for a flasher that would fit the wiring arrangement of my bike? Or can you suggest a design that might work, bearing in mind it is only a 2-wire unit with the only connection to vehicle earth through the indicator LED assembly? (C. L., via email).

● Traditional 2-wire flashers use a bimetallic strip that makes and breaks the electrical connection to the lamps. Generally, these were dependent on a certain lamp current to flash correctly and if a lamp blows, the flash rate becomes much faster, thus indicating the faulty bulb. If you substitute LEDs, their lower current would normally result in a rapid flash rate so you have been fortunate.

A flasher unit was described in the circuit notebook section of the August 1989 issue of Silicon Chip. It was designed to replace the original 2-wire flasher unit. However, it does not use two wires but the circuit shows how it can be used in place of the 2-wire flasher.

The circuit notebook circuit used a 555 timer and relay. The extra wiring involves obtaining a ground connection that is normally available from the chassis and so this should not be a problem. We have not described a 2-wire flasher. SC

WARNING!

Silicon Chip magazine regularly describes projects which employ a mains power supply or produce high voltage. All such projects should be considered dangerous or even lethal if not used safely.

Readers are warned that high voltage wiring should be carried out according to the instructions in the articles. When working on these projects use extreme care to ensure that you do not accidentally come into contact with mains AC voltages or high voltage DC. If you are not confident about working with projects employing mains voltages or other high voltages, you are advised not to attempt work on them. Silicon Chip Publications Pty Ltd disclaims any liability for damages should anyone be killed or injured while working on a project or circuit described in any issue of Silicon Chip magazine.

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[K301] $47

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[K299] $45.00

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[K300] $19.00

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12V/10W LED driver kit or 24v/20w with 2 series connected kits. This kit is designed to provide a constant Current to a series-parallel combination of nine 1.2W LED's that are enclosed in one assembly (1 X 10W LED). The total current remains relatively constant at around 1A with an applied battery voltage of 11-15V. The current reduces when the battery voltage falls below 11V, but some useful light output is still produced with a battery voltage as low as 9V. NOTE: For 24V / 20W wire 2 kits together in series, (requires the purchase of 2 K268B kits)

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[BKSW1]

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[BKSW3]

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[TX300]

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(V057)

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Includes 5 piece 8mm turning tool set

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